



Cardiff University
School of Computer Science and Informatics

**Enterprise Architecture: Managing an Oman Research and
Education Network (OMREN) Project Based on the TOGAF and
COBIT 5 Frameworks**

A thesis submitted in partial fulfilment of the requirement for the
Degree of Master of Science in
Computing and IT Management

By
Said Al-Maskari

Supervisor: Dr. Wendy K Ivins
Moderator: Dr. Natasha Edwards

September 2018

APPENDIX 1: Specimen Layout for Declaration/Statements page to be included in Taught Master's Degree Dissertations

CANDIDATE'S ID NUMBER	C1346289	
CANDIDATE'S SURNAME	Please circle appropriate value <input checked="" type="checkbox"/> Mr / <input type="checkbox"/> Miss / <input type="checkbox"/> Ms / <input type="checkbox"/> Mrs / <input type="checkbox"/> Rev / <input type="checkbox"/> Dr / <input type="checkbox"/> Other please specify	AL-MASKARI
CANDIDATE'S FULL FORENAMES	SAID AHMED NASSER	

DECLARATION

This work has not previously been accepted in substance for any degree and is not concurrently submitted in candidature for any degree.

Signed  (candidate) Date . 21/09/2018

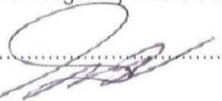
STATEMENT 1

This dissertation is being submitted in partial fulfillment of the requirements for the degree of (insert MA, MSc, MBA, MScD, LLM etc, as appropriate)

Signed  (candidate) Date . 21/09/2018

STATEMENT 2

This dissertation is the result of my own independent work/investigation, except where otherwise stated. Other sources are acknowledged by footnotes giving explicit references. A Bibliography is appended.

Signed  (candidate) Date .. 21/09/2018

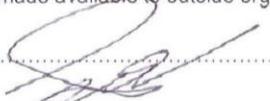
STATEMENT 3 – TO BE COMPLETED WHERE THE SECOND COPY OF THE DISSERTATION IS SUBMITTED IN AN APPROVED ELECTRONIC FORMAT

I confirm that the electronic copy is identical to the bound copy of the dissertation

Signed  (candidate) Date .. 21/09/2018

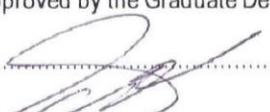
STATEMENT 4

I hereby give consent for my dissertation, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

Signed  (candidate) Date ... 21/09/2018

STATEMENT 5 - BAR ON ACCESS APPROVED

I hereby give consent for my dissertation, if accepted, to be available for photocopying and for inter-library loans after expiry of a bar on access approved by the Graduate Development Committee.

Signed  (candidate) Date .. 21/09/2018

Abstract

Over the last three decades, the enterprise architecture (EA) approach and EA frameworks have helped provide principles and outline best practice for architects to create optimal structure in organisations. EA frameworks have shaped architects' understanding by dividing enterprises into domains and providing models for each of those domains. This has enabled architects to build systematic structures to help decision-makers make appropriate choices when attempting to build long-term sustainable plans for organisations. If EA is integrated into an IT governance framework, it then becomes an ideal method for managing IT processes, aligned with the organisation's business strategy. EA serves as an imperative driving digital strategy, while also revealing new and innovative strategies to help bridge the gaps within organisations and even between interconnected agencies within the same organisation. This project is a continuation of a previous dissertation project submitted by Warda Al-Habsi at Cardiff University in 2016, in partial fulfilment of the requirement for the degree of Master of Science in Computing and IT Management (Al-Habsi, 2016). This aforementioned project was entitled, 'Developing a Partial Enterprise Architecture for the Oman Research and Education Network (OMREN)', where Al-Habsi covered the first four phases of the architecture development method (ADM) under the TOGAF framework. This current dissertation covers the other four phases of ADM based on the TOGAF 9.2 framework. In addition, it covers OMREN's IT Governance, in accordance with the COBIT 5 framework. An evaluation is presented at the end of this report, whereby both the usefulness and effectiveness of the two developments are measured.

Key words: COBIT 5, enterprise architecture (EA), information technology (IT), information technology alignment, IT governance, public sector enterprise architecture, TOGAF

Acknowledgments

First and foremost, thanks be to Almighty Allah for my life and the opportunity to pursue higher studies. However, thanks are also due to my parents for their love and support over the years. This gratitude extends to my brothers and sisters and naturally, to my dear wife and our children for standing by me throughout this process.

In addition, special thanks go out to Dr. Wendy Ivins, my supervisor and instructor during the entire Master's programme. This dissertation would not have been possible without her support and guidance, starting with the IT Management courses, right up until the writing up of my dissertation. I have deeply appreciated her patience, advice and feedback, which have clarified any areas of ambiguity encountered in this work.

Moreover, I must not forget to mention Warda Al-Habsi, the Applications Project Manager at OMREN for her invaluable support, advice and encouragement.

Finally, my thanks go out to all the helpful and supportive staff at Cardiff University, who have contributed to this very useful one-year programme, thus enabling me to gain valuable knowledge for my life and future career.

Table of Contents

Abstract.....	3
Acknowledgments	4
Table of Contents	5
List of Figures.....	8
List of Tables	9
List of Abbreviations	10
Chapter 1 – Introduction	11
1.1 Background	11
1.1.1 History of Enterprise Architecture (EA):.....	11
1.1.2 Overview of Enterprise Architecture (EA) and Alignment of Information Technology (IT) with Strategy.....	12
1.1.3 Variation in the Adoption of Enterprise Architecture (EA) by Country	12
1.2 Research Design.....	13
1.2.1 Problem Statement.....	13
1.2.2 Research Objectives and Scope	13
1.2.3 Research Methodology and Structure	14
Chapter 2 – Literature Review	15
2.1 Enterprise Architecture	15
2.1.1 What is an ‘Enterprise’?.....	15
2.1.2 What do the Terms, ‘Architecture’ and ‘Architect’ Signify?	15
2.1.3 What is ‘Enterprise Architecture’ (EA)?	16
2.1.4 Overview of ’Enterprise Architecture (EA) Frameworks’	18
2.2 Importance of Enterprise Architecture (EA) to Organisations	20
2.3 The Role of Enterprise Architecture (EA) in IT Infrastructure	22
2.4 Enterprise Architecture (EA) Frameworks	23
2.4.1 What is the Open Group Architecture Framework (TOGAF)?	23
2.4.2 Architecture Development Method (ADM):	25
2.5 Adoption of Enterprise Architecture (EA) in the Public Sector	27

Chapter 3 – Methodology: Developing the EA and the Governance Frameworks	29
3.1 Phase E: Opportunities and Solutions.....	29
3.1.1 Determine the Key Corporate Change Attributes	30
3.1.2 Review and Consolidate Gap Analysis Results from Phases B, C and D	31
3.1.3 Reviewing Consolidated Requirements across Related Business Functions.....	33
3.1.4 Consolidate and Reconcile Interoperability Requirements.....	33
3.1.5 Refine and Validate Dependencies	34
3.1.6 Confirm Readiness and Risk for Business Transformation.....	35
3.1.7 Confirm the Formulation of an Implementation and Migration Strategy.....	36
3.1.8 Identification and Grouping of Main Work Packages	36
3.1.9 Creating the Architecture Roadmap and the Implementation and Migration Plan.	38
3.2 Phase F: Migration Plan.....	39
3.2.1 Confirm Management Framework Interactions for the Implementation and Migration Plan	40
3.2.2 Assign a Business Value to Each Work Package	40
3.2.3 Estimate Resource Requirements, Project Timings and Delivery Vehicles	42
3.2.4 Prioritise the Migration Projects by Performing a Cost/Benefit Assessment and Risk Validation	43
3.2.5 Confirm Architecture Roadmap and Update Architecture Definition Document ..	46
3.2.6 Completing the Implementation and Migration Plan.....	46
3.2.7 Completing the Architecture Development Cycle and Document Lessons Learned	46
3.3 Phase G: Implementation Governance.....	47
3.3.1 Confirm Scope and Priorities for Deployment with Development Management...	48
3.3.2 Identify Resources and Skills for Deployment	48
3.3.3 Guide Development of Solution Deployment.....	51
3.4 Phase H: Architecture Change Management	52
3.4.1 Deploy Monitoring Tools	53
3.4.2 Manage Enterprise Architecture (EA) Risks	57
3.5 Architecture Governance Using COBIT 5 Framework	59
3.5.1 Introduction of Enterprise Architecture (EA) Governance:.....	59

3.5.2 Key Concepts:	60
3.5.3 Applying EA Governance:.....	61
3.5.4 Levels of Governance within the Enterprise:.....	61
3.5.5 Nature and Characteristics of Governance:	62
3.5.6 Technology Governance:	62
3.5.7 IT Governance:	63
3.5.8 IT Governance Framework (COBIT 5):	64
3.5.9 Applying COBIT 5 Framework for OMREN:.....	64
Chapter 4 –Reflection and Evaluation.....	79
4.1 Procedure for the Methodology	79
4.2 Limitations of the Research Methodology.....	79
4.3 Effectiveness of the Enterprise Architecture (EA)	80
4.3.1 Evaluation of TOGAF as a Framework for OMREN:.....	80
4.4 The Usefulness of Enterprise Architecture (EA) Governance.....	81
4.5 Personal Reflection and Evaluation	81
4.6 OMREN’s Evaluation of the Developed EA and IT Governance	82
4.7 Recommendations for Future Work.....	82
4.7.1 Modelling:.....	82
4.7.2 Analysis and Maintenance:	83
4.7.3 Completing the IT Governance:.....	83
Chapter 5 – Conclusion	84
References	85
Appendix A: COBIT 5.....	90
Appendix B: Evaluation Forms for the Developed EA	95

List of Figures

Figure 1: Context diagram for EA (Eitbokwiki.org, 2017)	17
Figure 2: Overview of the TOGAF framework content (The Open Group Architecture Forum, 2018).....	24
Figure 3: The TOGAF architecture development method (ADM) cycle (The Open Group Architecture Forum, 2018).....	25
Figure 4: Solution building blocks (SSBs) for OMREN's EA.....	34
Figure 5: OMREN architecture roadmap and implementation and migration plan.....	39
Figure 6: Matrix for assessing the business value and risks expected in OMREN	42
Figure 7: Spiral system development methodology	51
Figure 8: The basic 9-point check to confirm that the EA governance will get you more than half the way there (Source: Mar, 2012).....	60
Figure 9: Architecture governance framework - conceptual structure (The Open Group Architecture Forum, 2018).....	61
Figure 10: Characteristics of governance according to TOGAF (Naidoo, 2002).....	62
Figure 11: COBIT 5 Principles (COBIT 5, 2012)	65
Figure 12: The governance objective - value creation	66
Figure 13: The COBIT 5 goals cascade for OMREN (COBIT 5, 2012)	67
Figure 14: OMREN's e-library service goals cascade)	70
Figure 15: OMREN governance and management Using COBIT 5	71
Figure 16: OMREN enablers based on COBIT 5	73
Figure 17: Enabler performance management to measure enabler dimensions	75
Figure 18: RACI template proposal for OMREN (Racichart.org, 2018)	78

List of Tables

Table 1: Phases of TOGAF and the related activities (Josey, 2011)	26
Table 2: Implementation Factor Assessment and Deduction Matrix	31
Table 3: Consolidated gaps, solutions and dependencies matrix	32
Table 4: Assessment of the transformation risks (Al-Habsi, 2016)	35
Table 5: Accommodating the gaps based on TOGAF recommendations.....	37
Table 6: How the values are assigned according to impact type (positive or negative) ..	44
Table 7: Priority value for each project/system	45
Table 8: Gap analysis between the baseline and target application architectures (Al-Habsi, 2016)	48
Table 9: Comparison of the four nominated system development methodology (Cms.gov, 2008)	49
Table 10: Project screening proposal for OMREN project follow-up	56
Table 11: Customised enterprise goals for the e-library service	68
Table 12: Customised IT-related goals for the e-library service.....	69

List of Abbreviations

ADM	Architecture development method
BSC	Business scorecard
BSP	Business system planning
COBIT	Control objectives for information and related technologies
DODAF	Department of Defence Architecture Framework
EA	Enterprise architecture
EDM	Evaluate, direct and monitor
FEA	Federal Enterprise Architecture
FEAF	Federal Enterprise Architecture Framework
IS	Information systems
ISO	International Organisation for Standardisation
IT	Information technology
ITGI	IT Governance Institute
ITIL	Information Technology Infrastructure Library
NREN	National Research and Education Network
OMREN	Oman Research and Education Network
RACI	Responsible, accountable, consulted and informed
RAD	Rapid application development
SBBs	Solution building blocks
TAFIM	Technical Architecture Framework for Information Management
TOGAF	The Open Group Architecture Framework
TRA	Telecommunications Regulatory Authority
TRC	The Research Council of Oman
UML	Unified Modelling Language

Chapter 1 – Introduction

1.1 Background

1.1.1 History of Enterprise Architecture (EA):

The origins of the modern enterprise architecture (EA) approach can be seen in business system planning (BSP), which first emerged in the 1960s and appeared in its first edition in 1975. It was developed through the pioneering work of P.D. (Dewey) Walker, who designed the architectural document that structured BSP (Coetzee, 2018). BSP resembles the latest versions of the EA approach in many respects: identifying business objectives, defining business processes, analysing the IT infrastructure and identifying gaps to ensure optimal outcomes from IT strategy. However, most analysts and EA professionals agree that EA only really started to become a scientific framework through the pioneering approach of John A. Zachman in 1987 (Kotusev, 2016). Many authors in the literature consequently refer to him as the ‘father’ of EA. For example, most publications on this topic consider his framework paper to be the basis for the underpinning concepts of EA. Zachman was in fact originally a student of Walker and also contributed to the development of BSP. As such, Zachman’s EA framework has influenced many subsequent frameworks.

After Zachman’s framework, a large number of architectural frameworks started to appear in organisations. In 1994, the United States Department of Defence developed the Technical Architecture Framework for Information Management (TAFIM), later referred to as the Department of Defence Architecture Framework (DoDAF). This was followed by the Federal Enterprise Architecture Framework (FEAF) in 1996. Early in 1998, the Open Group Architecture Framework (TOGAF) had its first release, going on to become the best known architecture framework amongst enterprise architects. It played an important role in demystifying the architecture development process, which enabled information technology (IT) professionals to construct unique solutions, according to their organisations’ business requirements (Opengroup.org, 2018).

1.1.2 Overview of Enterprise Architecture (EA) and Alignment of Information Technology (IT) with Strategy

The discipline of EA mainly involves seeking to align an organisation's information system (IS), human resources, business processes, workplace culture, mission, and strategy. This alignment is intended to enhance an organisation's ability to manage complexity and resolve internal conflicts. Moreover, it helps organisations to adapt proactively to environmental change (Gladden, 2017).

EA evolved in the 1980s and 1990s as a methodology for organisations to achieve greater coherence, competence and strategic direction using computing technologies. Since then, it has grown to provide unique insights into the challenges and opportunities inherent within the transformation of technologies into the life of an organisation (Gladden, 2017).

1.1.3 Variation in the Adoption of Enterprise Architecture (EA) by Country

The EA approach has been found to perform well in structuring large organisations, especially in the private sector. As a result, the EA concept has started to gain more attention in the public sector over recent years, as public sector organisations have begun to adopt the working criteria set out by many private enterprises. According to Heikkilä and Penttinen (2016), more than 67% of the world's governments will eventually start adopting EA as an approach to enhance interoperability, eliminate overlapping projects, and support the reuse of working methodologies. In the UK, EA is established as an integral component of public-sector information architecture. As such, it is used to ensure that information and data can flow between government agencies, thus providing seamless, efficient, secure and trusted services (Heikkilä and Penttinen, 2016).

Numerous terms are used to refer to the EA concept, although 'enterprise architecture' is the one that is most commonly used in the private sector. However, governments tend to refer to it as national EA (NEA), while in the US, it is usually known as Federal EA (FEA). Meanwhile, the UK government has established cross-Government Enterprise Architecture (xGEA) as public sector information architecture (Heikkilä and Penttinen, 2016).

1.2 Research Design

1.2.1 Problem Statement

The concept of EA has been introduced and implemented in large private-sector organisations; proving its efficiency and success in creating well-structured organisations, with reliable alignment between IT systems and business goals. However, in the public sector, there have always been challenges to the adoption and deployment of the EA approach throughout organisations. Likewise, this was an issue for the Oman Research and Education Network (OMREN), when the original roadmap failed to acknowledge the need for a close relationship between IT and business objectives. Instead, OMREN implemented its roadmap as a general, albeit high-level, strategic plan that omitted many details from its management component. As a result, a need arose to rebuild OMREN's structural and management aspects, using a comprehensive framework to cover all architecture, management and governance issues; thereby enhancing its business capabilities and helping to pave the way towards robust EA.

1.2.2 Research Objectives and Scope

The aim of this research is to study the importance of applying EA frameworks in the public sector, with a special focus on IS/IT perspectives. A case study will consequently be conducted here on the OMREN project. The main objective is to address the gaps in the previous roadmap, as regards organisational structure and governance. This objective will be achieved by developing an EA for OMREN; aimed at adopting a methodology from the TOGAF Architecture Development Method (ADM) and the Control Objectives for Information and Related Technologies (COBIT 5) Framework. In short, the main objectives of this dissertation project may be listed as follows:

1. To study EA's contribution to building organisational infrastructure.
2. To define the alignment of IT strategy with organisational goals and business processes.
3. To develop an EA for the OMREN project as a case study; covering phases E to H of the TOGAF framework's ADM.
4. To develop an EA and IT governance framework for OMREN, using COBIT 5.
5. To evaluate the usefulness and effectiveness of the frameworks developed in this study.

1.2.3 Research Methodology and Structure

This research involves a descriptive method, which includes a case-study conducted on a real-life organisation. It therefore requires an in-depth study and analysis of the organisation's structure to gain a full picture of the problems involved and the formulation of appropriate solutions. The resulting dissertation has been structured as follows:

Chapter 1 – Introduction: This provides some background on the topic, as well as stating the research problem and giving a general description of the dissertation.

Chapter 2 – Literature Review: This provides in-depth background information about the dissertation topic, comprising EA and the alignment of IT with organisational objectives.

Chapter 3 – Methodology: This is the most extensive chapter; describing the development of EA (Phases E to H of ADM, based on TOGAF) and enterprise governance, including IT governance based on COBIT 5.

Chapter 4 – Discussion and Evaluation: This chapter evaluates the EA developed in the present study, as well as the corresponding governance framework, from the perspective of both the author and OMREN.

Chapter 5 – Conclusion and Recommendations: This chapter draws an overall conclusion concerning the work carried out on this project, using the chosen frameworks.

Chapter 2 – Literature Review

2.1 Enterprise Architecture

The management of any large or complex organisation requires 'architecture': a word that is generally associated with the construction of buildings (Lankhorst, 2017). However, a reference framework or plan is equally necessary when designing an enterprise. This helps create an overview of the structure of that enterprise and defines the basic components related to its business processes, applications, support and technical infrastructure, which are usually categorised into domains. Each domain expresses different aspects of the architecture of the enterprise concerned. This current section will now clarify in detail what constitutes EA.

2.1.1 What is an 'Enterprise'?

An enterprise is generally defined as a relatively large organisation (company, charity, government department, agency, etc.). However, it may also refer to any collaborative collection of sub-organisations with a shared set of objectives (Maguire and Sparx, 2017).

2.1.2 What do the Terms, 'Architecture' and 'Architect' Signify?

The architecture of a system may be defined as a description of its structure (components), behaviour (processes), and functions. Therefore, it is very helpful for protecting the essential business components, while at the same time allowing for maximum flexibility and adaptability in that organisation. In brief, it may be stated that the architecture will always serve as the key to success for any enterprise in its activities (Lankhorst, 2017).

Meanwhile, enterprise architects play a primary role in developing an organisation's EA. The metaphor for their role is commonly cited as that of the city planner, as it is city planners who realise a long-term vision to provide the roadmaps and guidelines for a city to manage its growth and ensure a comfortable existence for its citizens. Based on this analogy, various types of architect can be distinguished from each other through their job description in relation to building EA in an organisation. For instance, it could be said that a system architect is responsible for drafting the 'building' plans, while a software architect is responsible for its 'heating and air conditioning'. In contrast, the network architect is responsible for the 'plumbing, electricity and water supply network' in the building or between it and other buildings (Tabia, Benferhat and Ali, 2017). The parallel drawn between

an enterprise architect and city planner clarify the necessary activities and processes for drafting and implementing an organisational plan.

Notwithstanding the above, there are numerous responsibilities and skills that may be associated with an enterprise architect (Tabia, Benferhat and Ali, 2017). Van der Torre and Van Zee (2017) specify two main roles under which these tasks fall:

The engineer architect: The architect or group of architects who develop the business and IT models. These models can take the form of UML diagrams; specially tailored to the organisation's diagrams, risk analysis tools, textual description, or any other means of representation that the architect might feel comfortable about using for presenting his or her ideas.

The facilitator architect: The architect who usually acts as an intermediary between the IT and business areas. This architect normally attends business meetings and serves as an IT expert who is consulted by decision-makers and managers over specific IT solutions that are required.

To summarise, enterprise architects often work on large projects and in large agencies or organisations over time to help achieve long-term goals and visions, with an emphasis on IT aspects.

2.1.3 What is ‘Enterprise Architecture’ (EA)?

Definition (noun): Documentation describing the structure and behaviour of an enterprise (including its information systems [IS]).

Definition (verb): A process of describing an enterprise (including its IS) and then planning and governing change to improve the integrity and flexibility of the enterprise concerned.

EA is a powerful platform used to determine an organisation’s strategic situation. It is generally viewed as a discipline that stands out to help guide an organisation towards its planned objectives and to execute its initiatives (Maguire and Sparx, 2017). Furthermore, EA consists of principles and best practice that help guide an organisation in its strategy implementation by making any necessary changes to bridge gaps and achieve optimal implementation of organisational vision and objectives (Yesser, 2018).

According to Lankhorst (2017), amongst others, EA is a coherent whole made up of principles, methods and models that are used in the design and definition of an enterprise's organisational structure, processes, IS and infrastructure. Lankhorst argues that the most important feature of EA is its ability to provide a holistic image of the enterprise. This is achieved by capturing the essential components of the organisation's business processes, IT system and strategy.

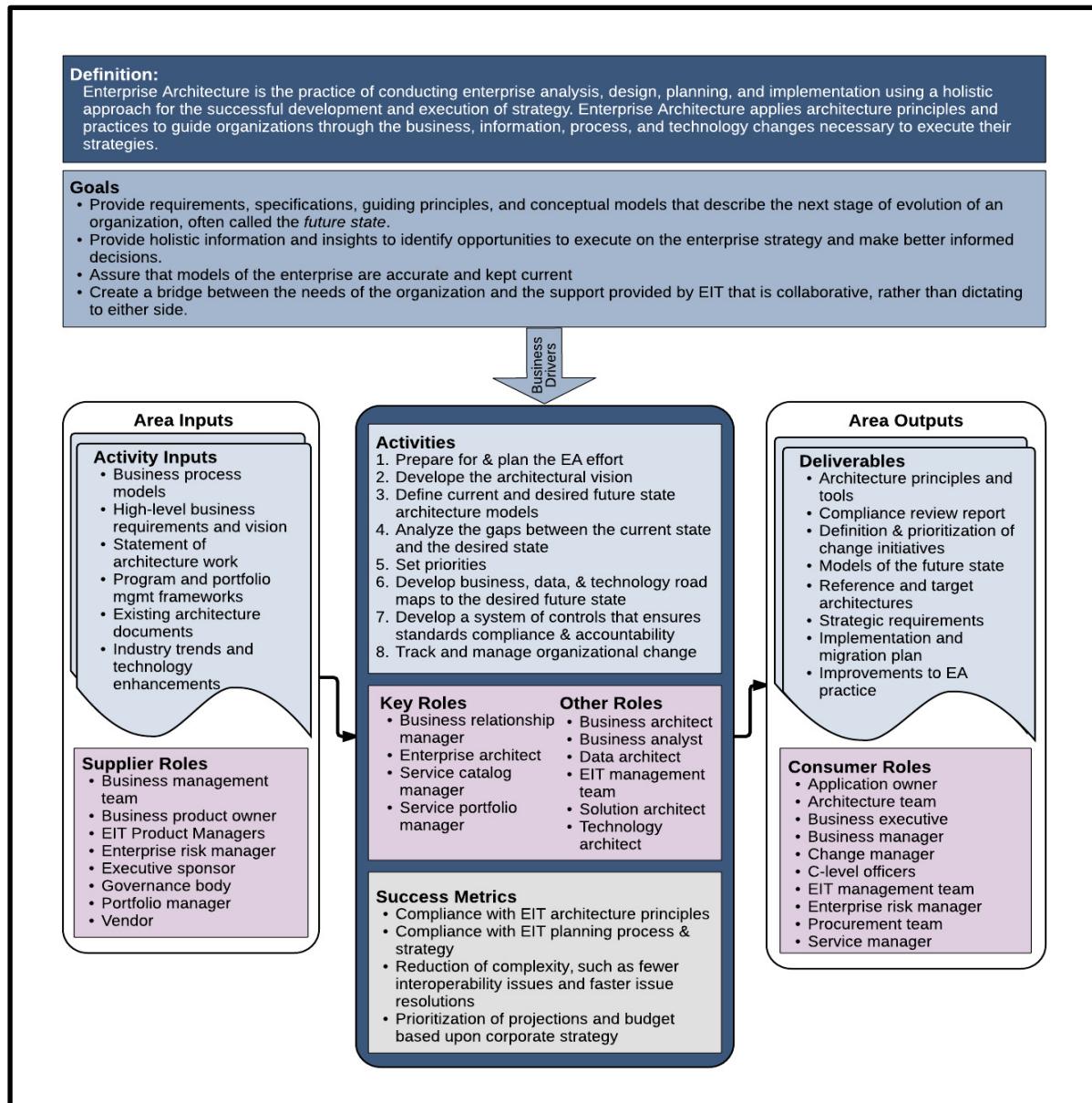


Figure 1: Context diagram for EA (Eitbokwiki.org, 2017)

To summarise, EA involves developing analysing, designing, planning and implementing a holistic approach to the successful development and execution of strategy. EA applies architecture principles and practices to guide organisations through changes to their business and other processes, information, and technology in the execution of strategy. The main goal of EA is to provide specifications, guiding principles and conceptual models for designing the next stage of an organisation, or its ‘future state’. It provides holistic information and insights to define opportunities and implement strategy to assist with decision-making. Moreover, it verifies the models and creates a bridge between an organisation’s requirements and the support provided by enterprise IT (Eitbokwiki.org, 2017). Figure 1, above, presents an EA context diagram relating to IT.

2.1.4 Overview of 'Enterprise Architecture (EA) Frameworks'

Numerous frameworks have evolved to clarify the concept of EA. The first of these was created by Zachman, as mentioned earlier, and this serves as a milestone in EA structure. Later, many other frameworks followed suit in the field, such as TOGAF and DoDAF, to name just two. In order to be able to differentiate between different frameworks and the ways in which they have evolved, they need to be explored from the following perspectives:

- **Content:** the structure or metamodel
- **Processes:** the activities that need to be performed.
- **Organisation:** the people and roles involved in creating and implementing the architecture.

2.1.4.1 Content (Breakdown):

Large enterprises can be very complex and require methods for reducing that complexity to smaller components, so that they can be dealt with. The first way to do this is by segmenting the organisation, so that if the enterprise is made up of subsidiary companies or is a large government organisation with many different agencies, it should clearly be divided up accordingly, as it will already be in different component parts.

The second way of doing this is to look at different domains. Most of the existing frameworks identify four domains. First, there is the business architecture domain, which focuses on the reason for the organisation’s existence. It covers things like the business objectives, goals, strategic thinking and other capabilities. Furthermore, it identifies the

processes, functions and organisational structure. Secondly, there is the data/information architecture domain, which relates to the IS layer that takes care of all the organisation's data. Thirdly, there is the applications architecture domain, which focuses on the IT applications providing services to the business. The triangular relationship between these three domains involves the applications domain helping to manipulate data on behalf of the business, while the applications provide these services to the business. This is described as business services being offered either internally or externally to customers. The fourth and final domain is the infrastructure (technical) architecture domain, which may be described as the nuts and bolts, wires and system software depended on by the business and data architecture.

A general overview of these four domains will reveal that they overlap; thereby locating the business map in relation to the data architecture and the point where the business architecture maps to the applications. In addition, it clarifies how the data and applications depend on the infrastructure domain. Typically, these relationships are represented in a hierarchical format, where the infrastructure layer offers services upwards to the applications, which in turn offer their services via business activities to the outside world. These are the four main domains in any architecture framework, although there are other domains that some organisations might wish to focus on, such as the security domain, which cuts across all the others. However, some organisations see the compliance domain as important, whereby specific compliance architecture is overseen as its own domain. Examples of other domains may be found in the frameworks designed by DoDAF and the Ministry of Defence in the UK (MoDAF) (Assist Knowledge Development, 2014).

2.1.4.2 Process - The Architecture Activities:

Creating Descriptions: creating architectural descriptions for each of the above-mentioned domains. These descriptions must be consistent and map to each other. However, if any sort of change is to be initiated in an organisation, there need to be at least two sets of description:

- **The baseline description:** describing the current situation
- **The target description:** describing the future situation.

Ordinarily, these describe the organisation's strategic vision, i.e. where the organisation wants to be within a timeframe of three to five years.

Gap Analysis: comparing the two situations listed above to identify any gaps or differences. What needs to change in these two types of architecture is the organisation's ability to move forward. This will involve some sort of strategic migration plan to outline how these various gaps will be filled, thus launching the individual change projects and programmes that the organisation intends to adopt and follow over the next few years (Assist Knowledge Development, 2014).

EA is not about planning or making changes, but rather about overseeing those changes and defining the various architecture principles and standards that should be applied by the relevant programmes and project teams. Architects are expected to govern these activities to ensure that the standards and principles are being followed and that the plans meet the organisation's actual needs.

2.1.4.3 Organisation - Purpose of EA over Time:

1990s and early 2000s: EA emerged from IT/IS functions and reflected the problems of the day, whereby siloed IT systems failed to interoperate very well with each other or share information. Therefore, organisations sought business processes that would cut across these silos.

Late 2000s - present: There is now a great deal of middleware that enables systems to communicate with each other. As a result, the focus has shifted towards business EA and a large number of organisations (applying TOGAF) have begun briefing up aspects of business architecture, which is very much about enabling businesses to change. IT is now frequently seen as a change enabler in many organisations. Good agile IT architecture allows businesses to implement change in processes and capabilities at a much faster rate than was permitted by the former rigid architecture (Assist Knowledge Development, 2014).

2.2 Importance of Enterprise Architecture (EA) to Organisations

The main role of EA is to analyse organisations and deliver information that will help architects and decision-makers leverage key resources and optimise the processes and functionalities of the enterprises concerned. Consequently, there are many different reasons why an organisation will decide to invest in an EA. The most important of these reasons is to align objectives with IT strategy. Other reasons for investing in EA include the desire to

optimise business processes, facilitate IT planning, increase the architectural conformity of projects and improve the organisation's management capabilities.

The main goal of EA is to identify gaps and set up the future state of the organisation's processes and IT strategy ('Target Architecture'). It provides a roadmap for achieving the target by studying the current state as a baseline ('baseline architecture'). The two key components of EA are the planning process ('definition') and the tangible outputs of that planning process ('representation'). These may be seen through the roadmaps, architectural diagrams, functional modifications and other artefacts (Tamm et al., 2011).

Numerous studies have provided explanations of how EA could benefit an organisation. A few dedicated studies with empirical evidence have given special attention to explaining the role of EA in achieving organisational benefits. They argue that to measure real benefits, an organisation should clearly differentiate between the benefits flowing directly from EA and the subsequent effect on the state of an organisation in the real world.

The direct benefits of EA are evident from an enterprise's business processes and IT systems, and the extent to which these processes can be shared between different departments and even between multiple agencies of the same organisation. Other direct benefits relate to increased knowledge of the organisation and its goals. This would become clear from a better understanding of the organisation's business processes or current IT systems. As a result, the decision-makers will be able to make precise decisions to achieve the organisation's objectives. Moreover, another direct benefit can be seen from enhanced communication between different stakeholders, which will help reduce the duplication of efforts and ultimately lead to shorter cycle times and improved performance (Bernard, 2012).

Conversely, the indirect benefit of EA is mainly built upon the EA-guided operating platform. This platform is likely to have a higher level of standardisation and integration, although studies tend to diverge in their claims concerning its benefits and discussion of related mechanisms. Nonetheless, Ross and Weill (2004) declare that through standardisation, EA enables an increase in possibilities and reduces the duplication of both human and technological resources. According to the study, the organisation's chance of success will increase with the aid of outsourcing; ultimately translating into lower IT costs and reduced time to market. In turn, this will enable an organisation to concentrate more on its core activities (*ibid.*).

Aside from the above, EA creates value for various levels of management in different aspects of an organisation, such as governance, strategy, business processes, information, applications, workforce management, security, and standards (Vries and Rensburg, 2008). Research has also shown that the EA approach could complement other organisational areas, such as strategic planning, strategy execution, quality management, IT governance, and IT service delivery, support and implementation (Lankhorst, 2013).

To conclude, the main reason an organisation would wish to build EA is to maximise its return on investments and improve its performance, as well as embracing any emerging technologies that support its business. However, when investing in technology, the organisation must ensure that it is worth spending the money. Moreover, it is also essential to ensure that the right technology purchasing decisions are made, so that the organisation can continue building profitability and bringing about improvements that will help achieve the organisation's overall objectives.

2.3 The Role of Enterprise Architecture (EA) in IT Infrastructure

EA creates the road map and guidelines necessary for matching business procedures and IT. Going back to the history of modern EA, it may be divided into two main eras. The first was between the 1990s and early 2000s, where EA emerged from IT/IS functions, as mentioned earlier. The second era began in the late 2000s and endures to the present, with a great deal of middleware that now enables systems to 'talk to each other'. Business EA has become more important, as also described previously.

In fact, during the last three decades, IT has played a major role in transforming the infrastructure and models in organisations, so that they can meet the challenges of the 21st century. IT strategic planning and management have diverted their concentration from mastering technology, developing IS, and controlling the cost of IT infrastructure to viewing IT as an essential means of achieving business value. In addition, they have been used to create a new organisational structure to boost the ability of innovation, competition and cooperation (Hugoson, Pessi and Magoulas, 2011). Hugoson, Pessi and Magoulas (2011) based their scheme on three significant trends: the use of IT to continuously influence every area of social and business life; IT investment issues that were previously the province of IT departments becoming a matter of concern to the whole organisation, and the increasing complexity and challenges of managing IT investment from a strategic point of view.

However, although there are methods and models for evaluating IT investment, it is still difficult for this to impact business. One of the most common reasons for this difficulty is that the larger the project or organisation, the more complicated it becomes to measure its business value. Another reason is that IT investments are frequently dealt with as stand-alone, rather than coordinated investments, which leads to them being unrelated to each other. Therefore, IT management must deal with uncertainties, conflicts, and continuously changing requirements. This is where EA comes into play; acting as a significantly improving factor of the IT department in any organisation (Marchand and Peppard, 2008).

2.4 Enterprise Architecture (EA) Frameworks

The first EA framework was introduced by Zachman in 1987 (Kotusev, 2016) and so in the literature, he is often cited as the ‘father’ of EA. Most publications on the topic consider his framework paper to be the foundation of basic EA concepts, later influencing other frameworks. Currently, TOGAF is the best known, most commonly recommended, and most widely used EA framework in the international sphere (Malik, 2018). This current project is a continuation of an older dissertation project on the development of EA by Al-Habsi (2016), who made comparisons between four frameworks: Zachman’s and the TOGAF, FEA and Gartner frameworks. The above author concluded that the most suitable framework for the OMREN project was TOGAF. Therefore, this current project has continued building upon the TOGAF framework as a basis for EA.

2.4.1 What is the Open Group Architecture Framework (TOGAF)?

Globally, TOGAF is one of the best known and most frequently used EA frameworks in both the public and private sector. The TOGAF standard is an architecture framework that provides methods and tools to assist with the acceptance, production, use and maintenance of EA. It is based on iterative process models and is supported by best practice (The Open Group Architecture Forum, 2018).

TOGAF is developed and maintained by the Open Group Architecture Forum. Its first version was released in 1995, based on the US Department of Defence’s TAFIM. The Open Group Architecture Framework has continued issuing new versions of the Framework at regular intervals. TOGAF can be used to develop a wide range of EA. A useful feature of TOGAF is that it can be used in conjunction with other frameworks, which are more apt to produce specific deliverables in the context of governments, telecommunications and

industry, finance, and defence. The key component of TOGAF is the method that is explained thoroughly in ADM. Most architects and practitioners use ADM to develop EA that meets business needs (Josey, 2011). Furthermore, using TOGAF can give a reflection of the structure and content of architectural capabilities within an organisation, as shown in Figure 2, below.

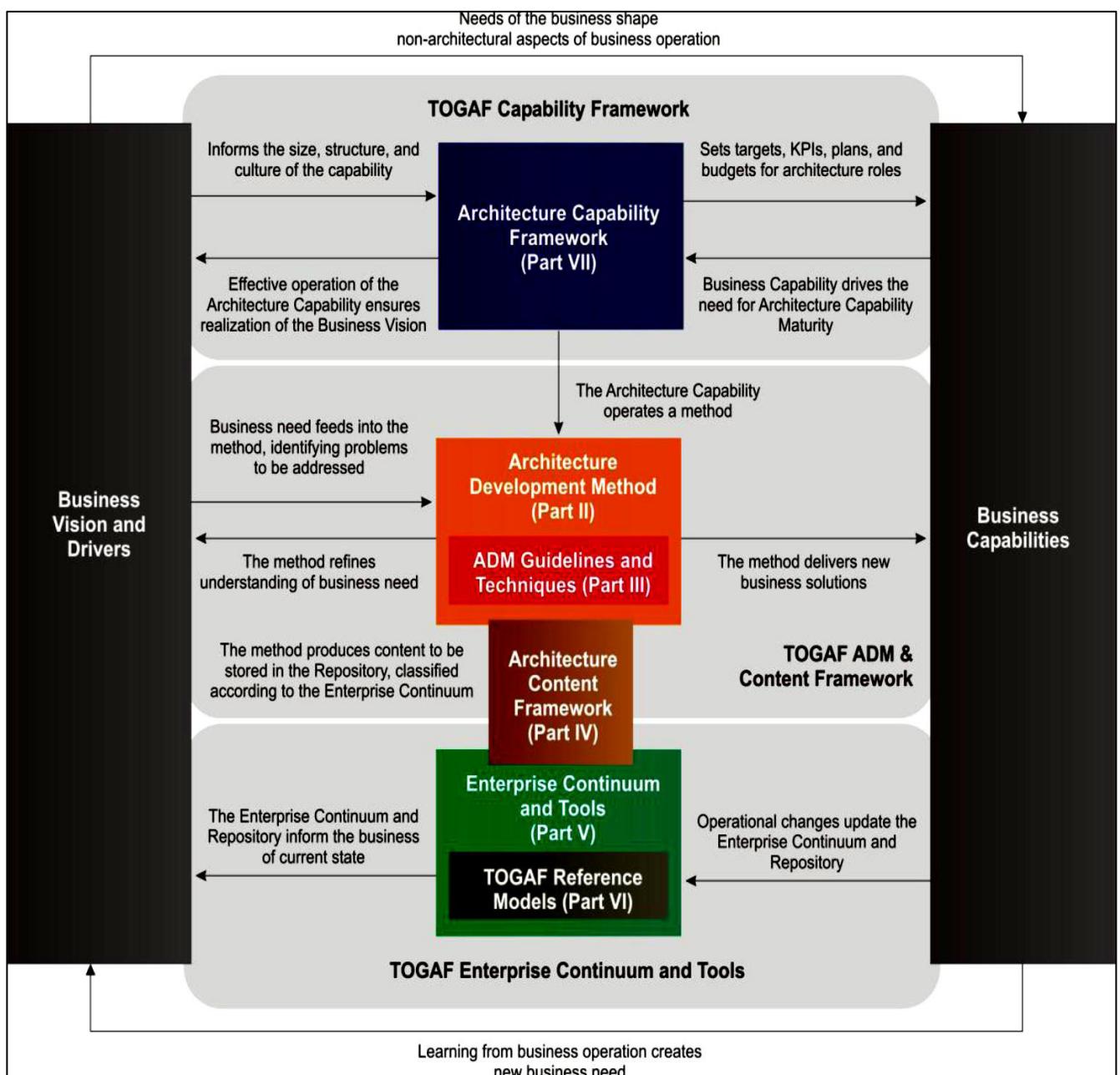


Figure 2: Overview of the TOGAF framework content (The Open Group Architecture Forum, 2018)

2.4.2 Architecture Development Method (ADM):

ADM is the core content of the TOGAF framework. It is a proven method of developing architecture and was specifically designed to address business requirements. It is an iterative set of architecture views, which will ensure that complex requirements are adequately met. The iterative feature permeates the whole process, both between and within phases. Each iteration involves new decisions that cover a high level of detail in the enterprise and within a time horizon. All these decisions are based on competence, resource availability and confirmed value, accruing to the enterprise (Weisman, 2011).

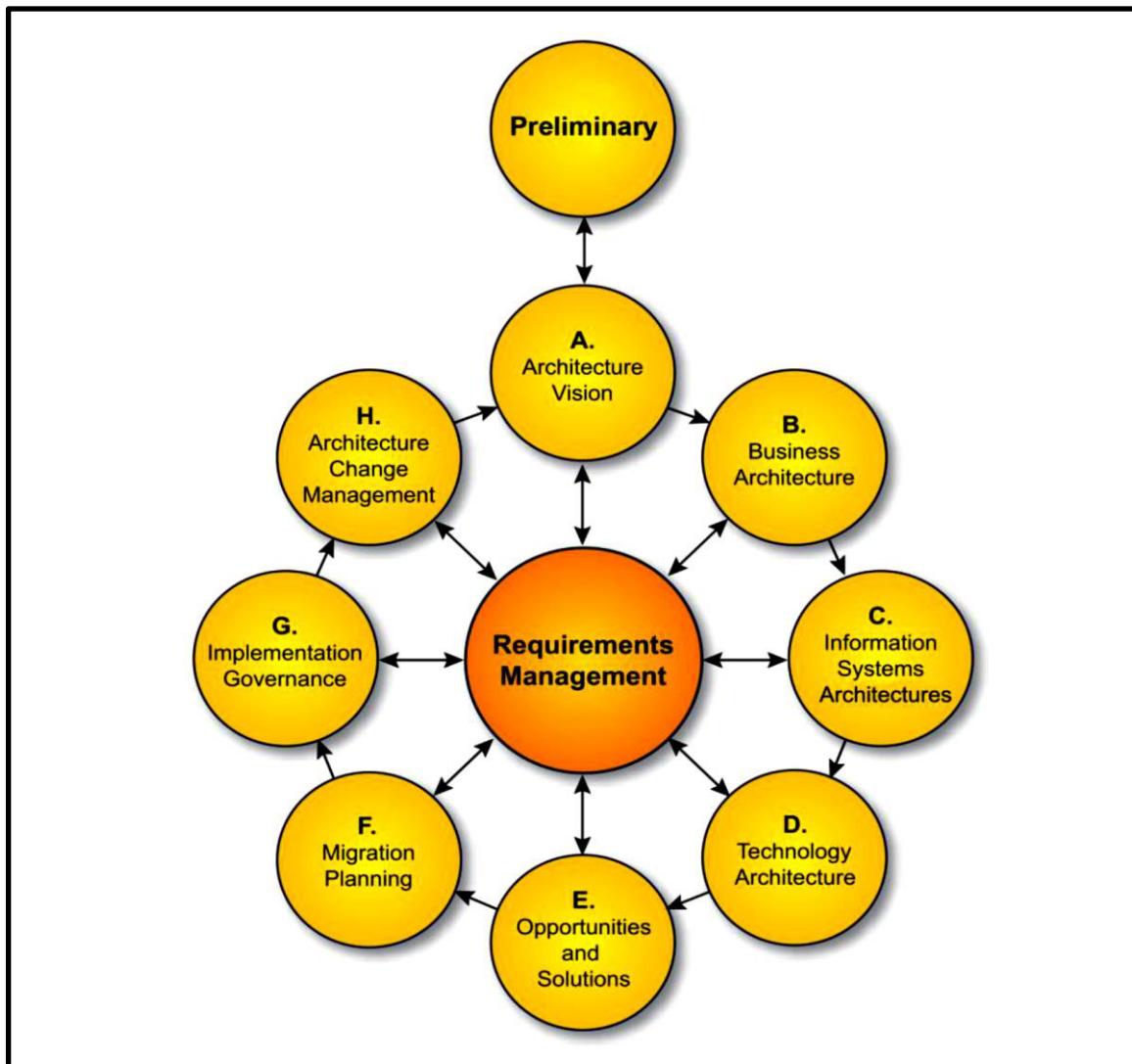


Figure 3: The TOGAF architecture development method (ADM) cycle (The Open Group Architecture Forum, 2018)

ADM clearly describes how to derive organisation-specific EA that addresses business requirements. It provides guidance to architects on the following levels (Josey, 2011):

- It works smoothly and neatly through a number of architecture development phases (business architecture, IS architecture, technology architecture), working in a cycle as an overall process template throughout the architecture development activity.
- In each architecture phase, it provides a narrative describing the objectives, approaches, steps, inputs and outputs. The inputs and outputs deliver a definition of the architecture content structure.
- It provides cross-phase summaries to manage requirements specifications.

Due to the importance of understanding ADM in TOGAF, each phase will be briefly addressed here to clarify its main idea and purpose. Table 1 shows each phase and the related activities (Josey, 2011).

Table 1: Phases of TOGAF and the related activities (Josey, 2011)

ADM Phase	Activities
Preliminary Phase	Undertaking the preparation and initiation activities required to create architecture capability, which sometimes includes the customisation of TOGAF, according to the organisation's requirements; selecting the proper tools, and defining the architecture principles. This helps organisations prepare for new EA.
Requirements Management	This is the central phase, upon which every stage of EA is based. Here, all the requirements are identified, stored and fed into and out of the ADM-related phases to assist with prioritisation.
Phase A: Architecture Vision	Setting the scope, constraints and expectations of any TOGAF project; creating the vision and identifying the stakeholders. The business context is also validated here, while a statement of the work is created and any approvals obtained.
Phase B: Business Architecture	Developing the architecture across four domains:

Phase C: IS Architecture (Application & Data) Phase D: Technology Architecture	1. Business 2. IS – Applications 3. IS – Data 4. Technology. In each domain, the gap is analysed, and the baseline and target architecture developed accordingly.
Phase E: Opportunities and Solutions	Identifying the drivers for delivering the building blocks determined in the previous phase, so as to be able to plan initial implementation. In this phase, it is determined whether an incremental approach is required to define the transition architecture.
Phase F: Migration Planning	Drafting a detailed implementation and migration plan for moving from the baseline to the target line.
Phase G: Implementation Governance	Providing an overview of architectural implementation and issuing architecture contracts; ensuring that the implementation project matches the architecture.
Phase H: Architecture Change Management	Monitoring the change management process to ensure that the architecture responds to the needs of the enterprise. This will ensure maximising the value of the architecture to the business.

2.5 Adoption of Enterprise Architecture (EA) in the Public Sector

Nowadays, organisations in any sector are keen to utilise technologies for building effective management and services. This is due to the diverse challenges of the information and telecommunications age. Public-sector organisations always face difficulties of this nature, which may be noted in the process of integration, interoperability, agility and transformation. The EA approach is widely considered as a promising solution to these difficulties. Moreover, the benefits of EA are also evident when dealing with other challenges, such as those faced when attempting effective strategic planning, enhanced decision-making and better business and IT alignment (Dang, 2018). Dang also argues that due to these benefits, a law on EA is necessary, as in countries like Finland and the US.

However, despite these benefits, numerous issues arise in EA practice. For example, organisations that adopt EA often struggle with limited signs of success, as a result of slow implementation and ineffective institutionalisation. Nevertheless, many cases have witnessed victories in this area, although the emphasis has mainly been on outcomes, rather than addressing the root causes of problems, or on strategies for effective EA adoption and the institutionalisation process. Therefore, more effort invested in these areas is likely to strengthen the adoption of EA in an organisation. This would likewise help architects and practitioners to improve the effectiveness of their EA adoption (Dang, 2018).

In developed countries, governments have a firm commitment to reforming the public sector, in order to reduce costs and increase the efficiency with which public and civil services are delivered. Moreover, governments are currently working hard to adopt technologies or approaches that will help stimulate national growth (Government of Western Australia, 2017). Aside from this, strategic realignment depends on organisations being redesigned. This requires government agencies to identify any business overlaps and duplication of services, in order to be able to reduce the number of agencies and merge them where appropriate, so that unnecessary costs can be cut and inefficiency eliminated.

Chapter 3 – Methodology: Developing the EA and the Governance Frameworks

This chapter covers the methodology of this dissertation project. The methodology will involve developing Phases E, F, G and H of the ADM in the TOGAF Framework. These four phases focus on the management aspect of EA for the OMREN project. After completing these four phases, an EA governance model will be developed, with an in-depth look at OMREN's IT governance, based on the COBIT 5 Framework.

3.1 Phase E: Opportunities and Solutions

This is the fifth phase of the TOGAF Framework's ADM. It is directly concerned with the implementation of the previously recommended outputs derived from the first four ADM Phases (A to D) (Al-Habsi, 2016). This Phase describes the process of identifying the vehicles (project, programs or portfolios) for delivering the target architecture defined in the previous Phases. However, the main objective of this Phase is to develop the initial complete version of the architecture roadmap, based on the gap analysis and the candidate architecture roadmap components generated from Phases B, C and D. It will also help determine whether an incremental approach is required to identify the transition architecture for delivering consistent business value to the organisation. The three main questions to be answered in this Phase are as follows:

- What are the changes required to realise the target architecture? (Work packages: a group of related changes within the project)
- Will there be any intermediate states during these changes? (Transition architectures: the possible intermediate situations between baseline and target architectures)
- What is the schedule of the delivery of changes? (An implementation and migration plan to provide a schedule for implementing the solution described by the transition architecture).

Phase E generates the first complete version of the architecture roadmap by combining the analysis and suggestions from Phases B, C and D. It focuses on how to deliver the architecture through mapping the required architectural changes to investment programs and projects. This will provide the findings and resources to carry out the packages for delivering

the transition and target architecture. The steps start by taking the outputs from earlier phases and consolidate them. Later, we analyse dependencies and reconcile differences to confirm again that the organisation can make the changes. Phase E refines the requirements, architecture documentation and architecture roadmap to produce the key output which is the first cut of the implementation and migration plan

3.1.1 Determine the Key Corporate Change Attributes

This step will determine how the EA can be best implemented to take advantage of the organisation's business culture. To achieve this, we should create an Implementation Factor Assessment and Deduction matrix to serve as a repository for architecture implementation and migration decisions. Following TOGAF recommendations, the matrix should include a list of factors to be considered. For each factor, we identify the description and the deduction that indicate the actions or the constraints that can affect the implementation of the plans. The factors usually can include risks, issues, assumptions, dependencies, actions and impacts. A Factor is a fact or situation that may potentially impact the implementation of the architecture. We can identify the factors based on the problem statement or the business cases created, and the gaps identified. The Deduction usually leads to extra work or a problem awareness reminder. Table 2, below, shows the factors that could affect OMREN's implementation and migration plan.

Table 2: Implementation Factor Assessment and Deduction Matrix

	Description	Risk: Deduction
Connect to the Physical Network	Changing from manual to automated registration	<p>Assumption:</p> <ul style="list-style-type: none"> - It will have a major change in the way that stakeholders are registered <p>Risk:</p> <ul style="list-style-type: none"> - Need for a new software system - Train staff to use the new system to approve the new registration applications - Automated database entry of stakeholder information <p>Dependencies:</p> <p>Needs a backup of the old database</p>
	Get OMREN connected to the outside world through a physical connection	<p>Vulnerability to viruses and hackers</p> <p>Dependencies:</p> <ul style="list-style-type: none"> - Dependent on the availability and continuity of service providers <p>Funding:</p> <ul style="list-style-type: none"> - Cost of service provider could increase over the years <p>Availability:</p> <ul style="list-style-type: none"> - Dependent on the quality of service delivered by the service provider (Omantel)
Collaborate Locally and Internationally	Subscribe to international organisations and NRENs	<p>Funding:</p> <ul style="list-style-type: none"> - The costs associated with international organisations such as GEANT and INTERNET2

3.1.2 Review and Consolidate Gap Analysis Results from Phases B, C and D

In this section, the gap output from Phases B, C and D are reviewed and consolidated into a single list. This can be done by creating a ‘Dependencies Matrix’, as recommended by TOGAF to provide and identify the solution building blocks (SSBs). Table 3 then shows OMREN’S consolidated gaps, solutions and dependencies matrix based on TOGAF and the outputs of Phases B to D from OMREN’s developed EA, namely the baseline and

architecture descriptions (Al-Habsi, 2016, pp.37-41). Based on the matrix in Table 3, below, the SBBs can be created for the architecture later, in order to address potential gaps.

Table 3: Consolidated gaps, solutions and dependencies matrix

No.	Architecture	Gap	Potential Solutions	Dependencies
1	Business	<ul style="list-style-type: none"> - Agreements with international research centres - Provision of a high capacity network 	<ul style="list-style-type: none"> - Subscription to at least two centres by the year 2021 - Get 100 organisations connected by the year 2012 	<ul style="list-style-type: none"> - International research centres and NRENs - Funding for NREN membership - Service provider solutions or collaborated government networks
2	Application	- Registration	Online registration	<ul style="list-style-type: none"> - Dependent on in-house developers' capabilities and time - Contract with a software development company
		- A common platform for the education community	e-Campus	
		- Single sign-on for all local education establishments	OMREN Federation	
		- Research submission	e-Research	
		- Virtual library	e-Library	
3	Information	Data centre	Provision of a local high specification data centre, specifically for OMREN's use	Funding
4	Technology	Creation of a reliable high-speed network	<ul style="list-style-type: none"> - Contracts with local service provider companies - Creation of own physical network 	<ul style="list-style-type: none"> - Funding - Local telecom service providers (Omantel, Ooredoo Telcom) - Creation of a collaboration with other government sectors to obtain a low-cost network between the regions in Oman
	Internal	Systems for HR, finance,	- Commercial off-the-	- Funding

	portal	supply chain and project management planning	shelf software to be implemented - In-house development	
--	--------	--	--	--

3.1.3 Reviewing Consolidated Requirements across Related Business Functions

Assessing the requirements, gaps, solutions and factors across the previous two sections for OMREN projects could help to integrate some of the work packages. Implementing the solutions from the Dependencies Matrix in section 3.1.2 for the target architecture leads us to some common functional perspectives. Analysing these solutions, we can see that there is not much to be implemented as a common solution for the new target architecture requirements. Based on that, we can get some significant benefit of consolidating all the systems required for the internal stakeholders such as HR, Finance, etc. to a single software developer or to one Off-the-shelf product that can cover all these requirements. Moreover, OMREN can use a ‘data centre’ solution to cover both the internal and external stakeholder software systems requirements to be as a consolidated repository. However, most of the other target architecture requirements must have a separate solution for each one as stated in Table 3 and mostly no sharing of solutions within any work package.

3.1.4 Consolidate and Reconcile Interoperability Requirements

According to the OMREN roadmap and by analysing the previous outcomes of the matrices created in sections 3.1.1 and 3.1.2, the requirements and solutions can be reviewed and consolidated to identify any constraints on interoperability required by a potential set of solutions. Based on TOGAF recommendations, the SSBs will be created to show conflicting building blocks and ultimately help make any required future changes to the specifications of these conflicting building blocks.

Refining the initial dependencies, we can confirm some of the issues that can be resolved or avoided in the migration plan. Based on that, we can also determine the best solution, opportunities and the sequence of implementation to create the ideal steps for a smooth migration. Studying all the required services shows that there will be some group activities that can be done concurrently. However, there will be some of the solutions that must be done incrementally in sequences and must be completed to ensure that all the services are available and well-presented.

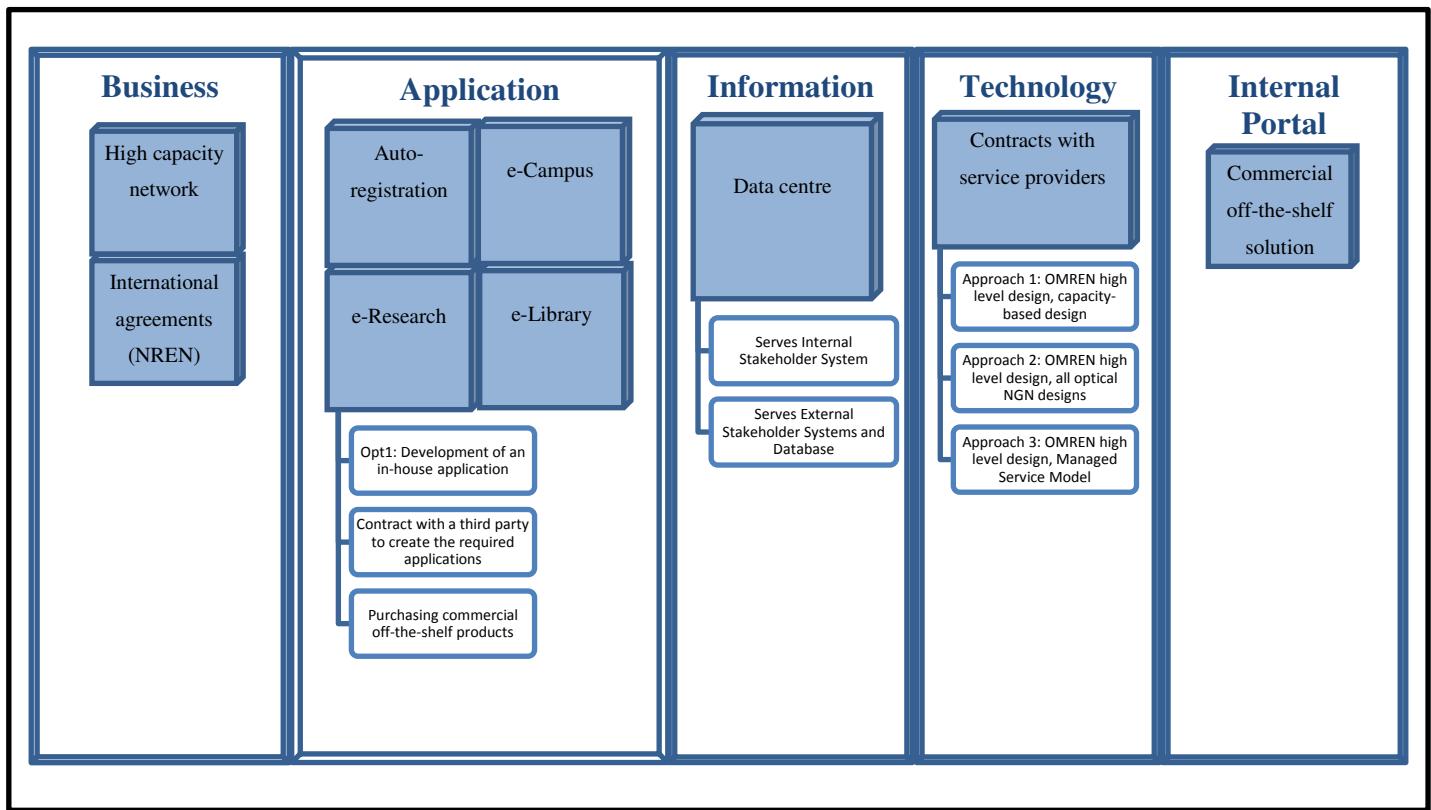


Figure 4: Solution building blocks (SSBs) for OMREN's EA

3.1.5 Refine and Validate Dependencies

This step identifies any constraints on the implementation and migration plan. Based on the original roadmap and strategic plan of OMREN, there should be no constraints on the identified dependencies. Studying the dependencies can group some of them to achieve the iterative approach in implementing the transition architecture and create a roadmap for the migration plan. In the case of OMREN, all the architecture requirements projects can be implemented concurrently. The most important factor is funding, and this was considered from the beginning of the project. Another major dependency that should be ready before the migration and implementation is the ‘Internal Portal’ which will enable the staff in OMREN to work smoothly during the migration because it will affect their performance especially in the supply chain and the project management plans. This can be seen in the Systems Decomposition and Users Interaction in the developed EA by Al-Habsi (Al-Habsi, 2016, p.43).

3.1.6 Confirm Readiness and Risk for Business Transformation

Transforming a business requires confirming the readiness and risks that may affect migration. Based on the analysis conducted in Phase A: Vision Architecture (Al-Habsi, 2016), the risks were identified and classified here, with the means of mitigation being measured. This will enable OMREN to implement its migration plan without any serious obstacles. It was noted that most of the risks were low to medium.

Table 4: Assessment of the transformation risks (Al-Habsi, 2016)

Risk	Description	Impact	Likelihood	Measures
Understanding the EA vision	There is risk associated with the top management misunderstanding the EA vision.	High	Low	Introductory workshop and meetings should be conducted before starting the work on the enterprise architecture project.
Funding	Complexities of getting funding support for the EA project.	High	Medium	Project scope should be clear and required funds must be declared before the final approval of the project.
Governance	Lack of team experience in managing and executing the enterprise architecture related activities.	Medium	Medium	The team should be prepared by conducting proper training courses. Invite experts from TRC and other organisations to join the project.
Accountability	Lack of understanding about roles and responsibilities amongst the team members.	High	Low	Clear explanation of roles and responsibilities should be provided to all the team members and involved departments.
Enterprise Capacity to Execute	The team size is small and this could be a challenge for managing and executing the OMREN and EA projects together.	Medium	Low	Members could be involved from the research and education organisations, as they are both impacted by projects.

The funding will depend on the TRC strategic plan and governance. As mentioned earlier, government funding requires a good governance plan to help mitigate the effect of this factor.

3.1.7 Confirm the Formulation of an Implementation and Migration Strategy

After conducting all the previous steps of this phase, we reach to the point where we need to create an overall implementation and migration strategy that will guide the implementation of the target architecture and structure any transition architecture if required. TOGAF suggests three approaches to implement the Solutions or exploit the Opportunities as follows:

1. **Greenfield:** A completely new implementation
2. **Revolutionary:** A radical change (i.e., switch on, switch off)
3. **Evolutionary:** A strategy of convergence, such as parallel running or a phased approach to introduce new capabilities.

Based on the roles and the current status of OMREN, the best option is to follow the third approach which will provide a parallel running and a phased methodology to introduce the new capabilities of the suggested EA.

The next step in this section is to determine the overall strategic direction that will address the risks identified in the matrix created in section 3.1.2 above. Again, there are three methodologies to implement this:

1. Quick win (snapshots)
2. Achievable targets
3. Value chain method.

Comparing the three methods, the most suitable is the value chain method. The overall goal of value chain analysis is to identify areas and activities that will benefit from the planned change to improve profitability and efficiency.

3.1.8 Identification and Grouping of Main Work Packages

According to the work done in sections 3.1.1 and 3.1.2, we can assess the missing business capabilities. For the new development, it is good to determine whether the work should be done in-house or through a contractor. For every gap/activity, we indicate whether the solution should be oriented towards new development, or be based on an existing product, and/or use a solution that can be purchased. An existing system may resolve the requirement with minor enhancements. For new development, this is a good time to determine whether the

work should be conducted in-house or through a contract. TOGAF recommends classifying the current and proposed systems as three methods:

- **Mainstream:** Part of the future information system.
- **Contain:** Expected to be replaced or modified in the planning horizon (within the next three years).
- **Replace:** To be replaced in the planning horizon.

According to OMREN's strategic plan and Phase B of the developed EA (Al-Habsi, 2016, p.24), which defines the Target Architecture and Gap Analysis, we can accommodate the gaps based on TOGAF. Table 5 identifies the classification of each project according to the categories: Mainstream, Contain and Replace.

Table 5: Accommodating the gaps based on TOGAF recommendations

Work Package	Solutions	Implementation Methodology		
		Mainstream	Contain	Replace
Registration	Online registration system			*
Business management	Connect to the physical network		*	
	OMREN Federation			*
	Collaborate locally & internationally		*	
	e-Research			*
	e-Library			*
	e-Campus			*
	Data centre		*	
Stakeholder management	Finance	*		
	HR	*		
	Supply chain		*	
	Project management planning		*	
Business planning & evaluation	Business rules and standards	*		
Financial management	Funding	*		

3.1.9 Creating the Architecture Roadmap and the Implementation and Migration Plan

This step consolidates the work packages into an architecture roadmap. A timeline shows the progress from the Baseline Architecture to the Target Architecture. Consequently, a clear set of outcomes can be seen easily with time, which can help OMREN management create a clear vision of the implementation and migration plan. The plan demonstrates the activities necessary to realise the roadmap. All the details of the roadmap must be aligned with the migration plan according to the output from Phases B, C and D.

The roadmap can also help in achieving an ‘Iteration Approach’, where applicable in the implementation plan. Moreover, the plan can support with the decision to adopt the best approaches for implementation such as a data-driven sequence, where the systems that create the data are implemented first and later create applications that process the data and provide the service. A clear understanding of the dependencies and life cycle is required to achieve this point. In the below roadmap for OMREN (see figure 5), we can clearly spot the dependencies. For instance, the Data Centre is essential to be completed before starting providing the main services to the stakeholders. Another example, the HR and Finance systems must be stable and functioning before of the supply chain and project management planning.

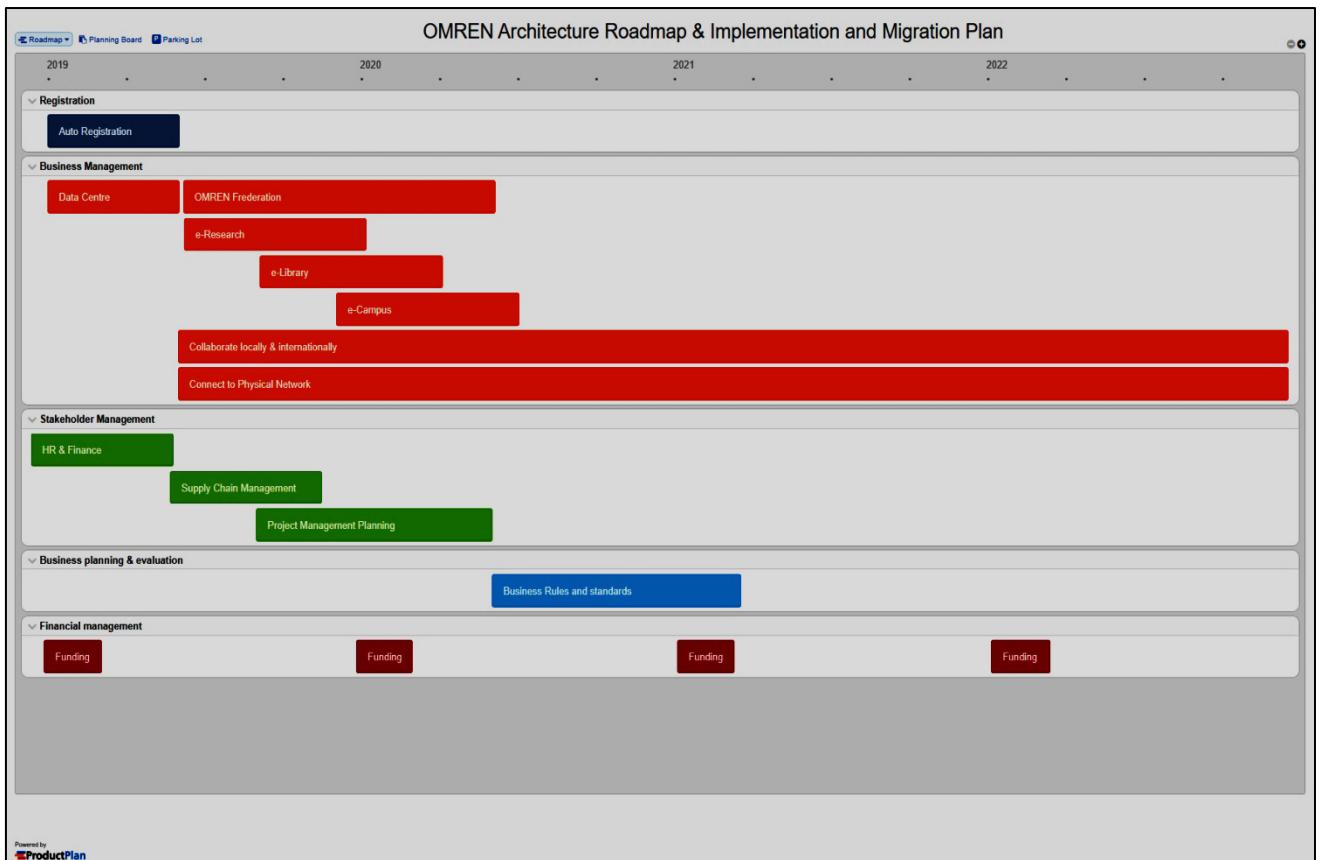


Figure 5: OMREN architecture roadmap and implementation and migration plan

3.2 Phase F: Migration Plan

Phase F aims to address the migration plan which is mainly dependent on the scope and goals of the overall architecture effort. It goes through many steps based on TOGAF recommendations. Achieving a good migration plan requires performing many activities regarding assigning the business values to each work package or projects. These activities have to be initiated during implementing the steps and must be closed during the architecture development cycle. Moreover, the order of the steps timing should be adapted to the situation at hand in accordance with the established architecture governance. Furthermore, a prioritisation plan is created by performing a cost/benefit assessment and risk validation.

3.2.1 Confirm Management Framework Interactions for the Implementation and Migration Plan

This step will coordinate the implementation and migration plan with the management framework in OMREN. Four management frameworks should work closely together for the plan to be successful:

- **Business Planning** that directs and provides the resources for all the activities required to achieve concrete business objectives/outcomes.
- **Enterprise Architecture** that structures and gives context to all enterprise activities delivering concrete business outcomes primarily, but not exclusively in the IT domain
- **Project/Portfolio Management** that coordinates, designs, and builds the business systems that deliver the concrete business outcomes
- **Operations Management** that integrates, operates, and maintains the deliverables that deliver the concrete business outcomes

The implementation and migration plan will affect the output of these frameworks and will be reflected in them. The plans are coordinated and integrated briefly into each of the frameworks. The outcomes of this step may be the real implementation which could be part of a different plan produced by another one of the frameworks with the original Enterprise Architecture.

3.2.2 Assign a Business Value to Each Work Package

This section establishes and assigns a business value to each of the work packages proposed in phase E (see section 3.1.8 Identify and Group Major Work Packages). The starting point is identifying what creates the most business value within OMREN. We need to organise and analyse all the work packages and recognise the importance and prioritise them. There are many criteria for addressing this activity, but we will consider the most relevant points to our project:

Return-on-investment criteria: Used by high-level management to monitor and confirm the progress of architecture transformation.

Business value criteria: Must be defined to measure the role in achieving the tangible business outcomes. It is mostly used to allocate resources in cases where there is business

value in conjunction with return on investment to determine whether a specific work to proceed, delayed or sometimes cancelled.

Critical success factors: Provides managers and implementers with a gauge of the most successful implementation.

A measure of effectiveness: This is a performance criterion that shows how the organisation will generally be affected by a specific work package.

Strategic fit criteria: Based on the overall EA, this will allow the approval of any new project or initiative and for determining the value of any deliverable

The next step of this section is to use the risks identified in phase A and assign them to projects by aggregating them with the help of the Consolidated Gaps, Solutions and Dependencies Matrix created in Phase E. Based on TOGAF recommendations, this can be achieved by estimating the business value for each project using the Business Value Assessment and Risk Validation. The **value** index should include criteria such as compliance to principles, strategic alignment, competitive position and financial contribution. The **risk** index should include criteria such as size and complexity, organisational capacity, technology and impact of a failure. Each criterion should be assigned an individual weight. Figure 6 illustrates the matrix for assessing the business value and risks expected in OMREN project. The values in the figure were obtained during this project as a feedback from OMREN senior management. We notice that most of the projects are ‘on target’, except two of them which are justified by OMREN in their feedback. The ‘Online Registration’ is a critical service for but there are complexities on the requirements of being a member of this network, and the process of registration is difficult to be automated. Therefore, it is still not implemented. For the e-campus, it was difficult to convince all members of OMREN to agree on the specifications and workflows of the mentioned system.

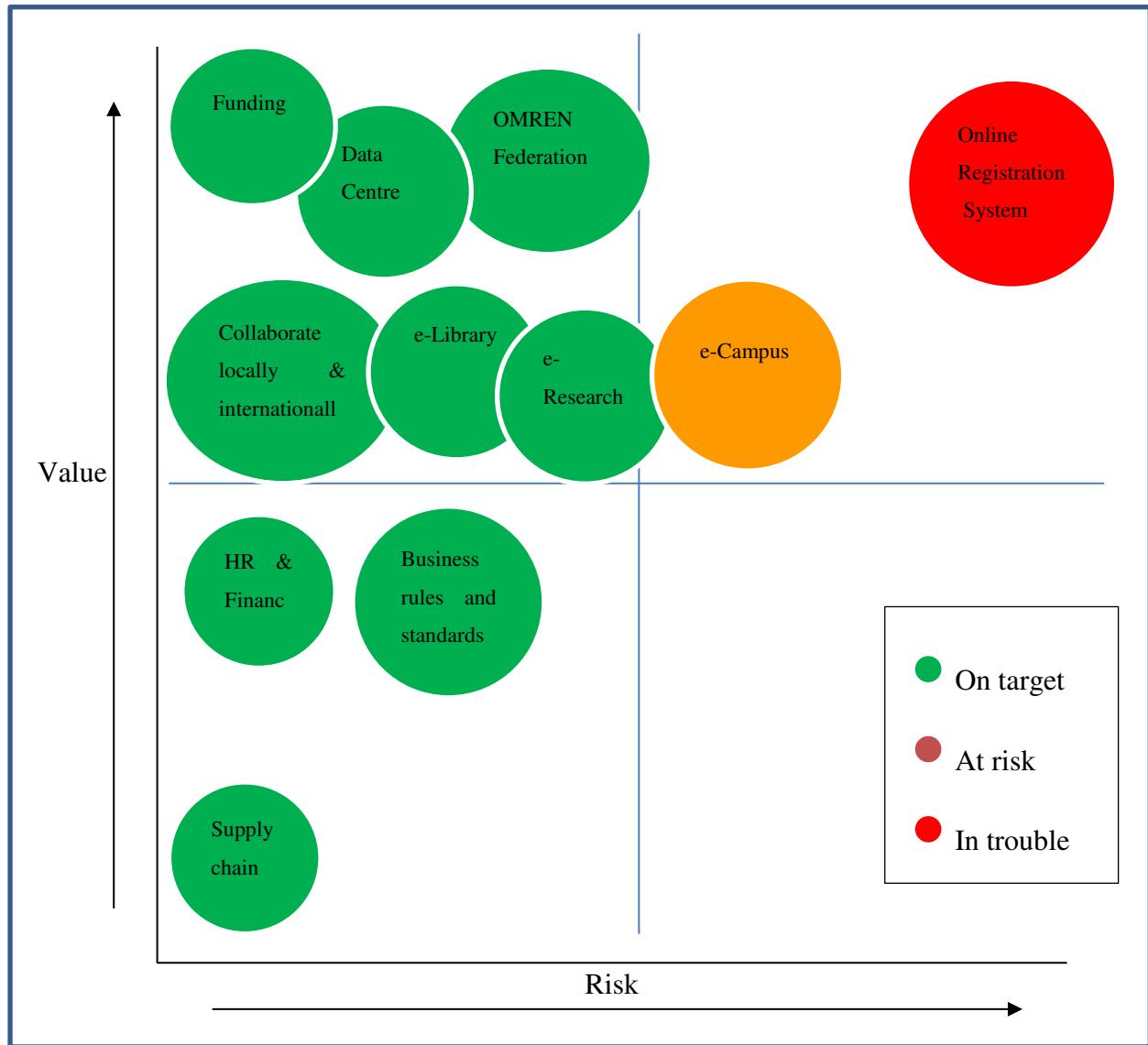


Figure 6: Matrix for assessing the business value and risks expected in OMREN

3.2.3 Estimate Resource Requirements, Project Timings and Delivery Vehicles

In this step, we determine the required resources and times for each project within the work packages. The projects are evaluated to figure out the initial cost estimates. The costs are then broken down into capital to create the budget. Moreover, the operation and maintenance are taken into consideration to make sure everything will run in a sustainable manner. The existing systems are decomposed to find if there are opportunities where the costs associated with delivering new or better capability can be offset. At the end of this step, we assign the required resources to each activity and aggregate them at the project increment and project

level. This step is beyond the scope of this dissertation and can be done in the future by OMREN's top and middle management.

3.2.4 Prioritise the Migration Projects by Performing a Cost/Benefit Assessment and Risk Validation

This step helps to prioritise the projects of the work packages by confirming their business value compared to the cost of delivering them. The benefit of each service as a work package should be determined clearly with its contribution to the SSBs of the OMREN project. Moreover, the risks mitigation that has was in Phase A is to be verified. After that, the required consensus can be gained to create a prioritised list of the projects that will provide a good basis and foundation for the resource allocation and gives the maximum value to the organisation.

To execute the above-mentioned recommendations, I will use the findings from phase A of the developed EA (Al-Habsi, 2016) for Assessment of Transformation Risks. Moreover, because the cost estimates are beyond the scope of this dissertation, I will use my understanding of the importance of the services to be delivered by OMREN according to their business value. These two factors will assist in concluding this step objective which can be seen in Table 6.

Prioritisation criteria and values: if the impact is **Positive**, 'Critical' is considered the highest value, namely 4 and 'Low' is indicated by the lowest value of 1. Adversely, if the impact is **Negative**, 'Critical' is the lowest value of 1 and 'Low' is indicated by the value of 4. Table 6 clarifies the value assignment criteria (Pmoguru.com, 2016).

Table 6: How the values are assigned according to impact type (positive or negative)

Type of impact Value criteria	Positive Impact	Negative Impact
Critical=4, High=3, Medium=2, Low=1	<ul style="list-style-type: none"> - Contribution to strategic objectives - Income <p>(If the impact is high, it will receive 4 points and if the impact is low, it is indicated as 1 point)</p>	
Critical=1, High=2, Medium=3, Low=4		<ul style="list-style-type: none"> - Execution risk - Human resource requirements - Cost <p>(If the impact is high, it will receive 1 point and if the impact is low, it will receive 4 points)</p>

How projects are prioritised: Table 7 shows the values assigned to each project based on the assessment criteria. Analysing the results from the Total column, we can see that the most important projects as a kick-off are the Data Centre, the Online Registration System and Collaboration Locally and Internationally. These are followed immediately by the other major systems such as e-Library and e-Research. On the other hand, the table illustrates the importance of internal systems such as the HR and Finance. The least important components of the organisation are the Supply Chain and Funding which is due to the nature of the organisation that gets its funding from the Government considered as a guaranteed financial allocation.

Table 7: Priority value for each project/system

Project/ Work Package	Positive Impact Critical= 4, High=3, Medium=2, Low= 1		Negative impact Critical= 1, High=2, Medium=3 Low= 4			Total
	Contribution to Strategic Objectives	Benefit	Cost	Execution Risk	Human Resource Requirements	
Online Registration System	4	4	2	3	2	15
Connection to the Physical Network	4	4	2	2	1	13
OMREN Federation	3	1	2	4	2	12
Collaborating Locally & Internationally	4	4	2	4	1	15
e-Research	3	1	2	2	2	10
e-Library	3	2	2	2	2	11
e-Campus	1	2	2	2	2	9
Data Centre	4	4	4	2	2	16
Finance	1	1	4	4	4	14
HR	1	1	4	4	4	14
Supply Chain	2	1	2	2	1	8
Project Management Planning	2	1	2	4	1	10
Business Rules and Standards	1	1	2	4	2	10
Funding	4	1	1	1	1	8

3.2.5 Confirm Architecture Roadmap and Update Architecture Definition Document

In this step, a completed Implementation and Migration Plan is issued based on the details gathered so far. This step is brought together with the accepted planning and management techniques. It should include integrating all the projects and activities with the dependencies and impact of change into a full project plan with capturing any external dependencies. In OMREN, the external dependencies are mostly stakeholders such as TRC and TRA. Moreover, there are some other external dependencies such as the service providers (Telecom companies) and the funding by the Government.

3.2.6 Completing the Implementation and Migration Plan

The migration plan for OMREN does not have many obstacles due to the preparedness and clear gap analysis done earlier. Nonetheless, the developed EA by Al-Habsi states that there will be a data migration minor issue (Al-Habsi, 2016). OMREN runs under TRC supervision and structure. As a result, there will be a requirement to consider the migration of data from TRC to OMREN. Both parties should agree on migrating the research services that are currently provided by the TRC. Therefore, a complete, clear and accurate migration plan should be produced before the data transfer.

3.2.7 Completing the Architecture Development Cycle and Document Lessons Learned

This step is about transferring from development of the architecture to realisation and comprehension of the architecture. If the maturity of the Architecture Capability warrants, an Implementation Governance Model is to be produced. All the lessons learned during the development of the architecture should be documented.

The details of the Architecture Roadmap and Implementation and Migration Plan are to be expressed at a similar level of detail to the Architecture Definition Document developed in Phases B, C and D. This will enable OMREN getting the required level of detail and prepare for the implementation and transition. It should also be available for the practitioners and management of OMREN where necessary to iterate another or part of the ADM cycle with a lower level of detail to manage and respond to the ongoing changes in the organisation where applicable.

3.3 Phase G: Implementation Governance

Phase G aims to assist in achieving successful management of the various implementation projects among the work packages in the proposed architecture. All the projects are brought together in parallel for the execution of the development process where the actual development happens. This ensures conformance with the target architecture by the implementation of the projects. Moreover, it applies any appropriate performance changes required using the architecture governance functions for the whole solution. The outputs will show dependencies, costs and benefits of the various migration projects in the final version of the implementation and migration plan. The architecture development cycle is completed here with lessons learned to enable continuity of the EA process.

Moreover, this phase provides an architectural oversight of the implementation. Implementation governance ensures that the projects and work packages comply with the target architecture by carrying out suitable architecture governance processes for the solution and managing any implementation driven architecture change requests. The actual development and implementation take place in parallel with this phase. Therefore, it makes sure that implementation projects and other ongoing projects are compliant with the defined architecture.

Typically, the target architecture is developed as a series of transitions or work packages to realise the business values and benefits as soon as possible and to reduce risk in the transformation program. Each transition represents an incremental step towards the targets delivering business benefits. By the time we start this phase, the architecture that has been developed in Phases A to D and the opportunities and solutions for delivering the architecture have been identified in Phase E, and the detailed implementation and migration plan has been finalised in Phase F. Henceforth, the role of the architecture team in now is clear and all about providing an architectural overview of the implementation. This is done by confirming the scope and priorities for deployment which helps guiding the development, solutions deployments and performing reviews.

An architecture contract document is used to drive architecture change that was produced at the beginning of this phase and approved by the architecture functions, the developers and internal stakeholders responsible for the implementation and deployments. This will be the mechanism for assessing compliance in architecture governance.

3.3.1 Confirm Scope and Priorities for Deployment with Development Management

This step reviews the migration plan, produces recommendations on deployment and consequently identifies the EA priorities for the implementation and development teams. Moreover, it identifies the deployment issues and makes recommendations and replacement building blocks. The solutions architects identify the gap analysis performed in the EA and solutions framework. This will conclude the SBBs to fill the gaps. The SBBs may have a one-to-one or many-to-one relationship with the projects or work packages. This will confirm if there are projects that may be working on the same capabilities and the architects will be able to ensure they can leverage the best value for the investments. To conclude, the output of this step is producing a Gap Analysis which can be seen in Table 8.

Table 8: Gap analysis between the baseline and target application architectures (Al-Habsi, 2016)

Target Architecture ➡ Baseline Architecture ⬇	Online Registration	OmanKID	OMREN Portal	e-Research	e-Campus	Intranet Portal	ERP	Eliminated Services ⬇
Manual Registration								Eliminated
OmanKID		Included						
TRC Intranet						Included		
TRC ERP							Included	
New ➡	Gap: Enhanced service to be developed		Gap: To be developed	Gap: To be developed	Gap: To be developed			

(Source: Al-Habsi, 2016, p.49)

3.3.2 Identify Resources and Skills for Deployment

There are many deployment resources which need to be realised in the overall EA deliverables and expectations from the all the projects and work packages. In this step, according to TOGAF, we should address the following considerations for OMREN project:

- Identify the system development methods for developing the solutions.
- Ensure the systems development method provides feedback to the architecture team.

Many development methodologies that can be used in OMREN project. A methodology refers to the framework that will be used to structure, plan and control the processes of the development projects. We will compare a few nominated methodologies by their strengths and weaknesses to be able to choose the ideal methodology which leads to the best approach.

This will be a short and focused comparison between the following methodologies:

- Waterfall
- Incremental
- Spiral
- Rapid Application Development (RAD)

Table 9 shows a detailed comparison of the four methodologies which are proposed to be used by OMREN as a development methodology.

Table 9: Comparison of the four nominated system development methodology (Cms.gov, 2008)

Methodology	Strengths	Weaknesses	Most Appropriate	Least Appropriate
Waterfall	<ul style="list-style-type: none"> • For less experienced teams • Step by step development (strict control) • Easily measures progress • Saves resources 	<ul style="list-style-type: none"> • Not flexible, slow • Difficult to iterate • Hard to go backwards • Difficult to find problems until testing • Vast amounts of documentation 	<ul style="list-style-type: none"> • Large projects • Projects with clear objectives • No pressure on immediate implementation • Inexperienced project managers 	<ul style="list-style-type: none"> • Projects with unstable objectives • Web information systems • Leading-edge applications
Incremental	<ul style="list-style-type: none"> • Potential in incremental knowledge from other phases or sub-projects • Moderate control is maintained • Can provide excellent project status throughout the lifecycle • Mitigate architectural risks • Monitor changes and make changes accordingly 	<ul style="list-style-type: none"> • Similar to a mini waterfall which lacks overall consideration of technical requirements • Completion of some projects earlier than those that require well-defined interfaces • Hard problems are postponed 	<ul style="list-style-type: none"> • Large projects • No well-defined requirements • Web information s and event-driven systems • Leading-edge applications 	<ul style="list-style-type: none"> • Very small projects of short duration • Very low-risk projects • Interactive applications where data for the projects already exists

Spiral	<ul style="list-style-type: none"> • Improves risk avoidance • Helps choose the best methodology based on risk assessment • Can merge waterfall and incremental methodologies 	<ul style="list-style-type: none"> • Difficult to decide the most appropriate combination of methodologies in each iteration. • Requires a skilled project manager • No definite control for moving from one cycle to another • Deadline is not firm 	<ul style="list-style-type: none"> • Critical or real-time systems • High priority risk avoidance • Non-strict resources • Highly skilled staff • High degree of accuracy • Implementation has more priority than functionality 	<ul style="list-style-type: none"> • Risk avoidance is not very important • No requirement for high level of accuracy • Not important to minimise resources • Functionality is more important than implementation
Rapid Application Development (RAD)	<ul style="list-style-type: none"> • Functioning version of the development is ready faster • More business focus and lower cost • Higher level of both business and technical stakeholders • More focused on users' point of view of the requested elements • Savings in terms of financial and human resources 	<ul style="list-style-type: none"> • Can cause lower quality due to speed and low cost • Risk of misalignment due to missing information • Good for added features through the development process • May lack scalability • Formal reviews are difficult 	<ul style="list-style-type: none"> • Small-to-medium projects • Project scope and business objectives are focused • Visible functionality • Availability of senior management involvement • Skilled business and technical teams • Availability of data for the projects • Well-defined technical architecture 	<ul style="list-style-type: none"> • Very large projects with distributed information systems • Real-time and safety are critical • Complex systems with high data analysis requirements • Unclear scope and objectives • Unavailability of decision-makers on a timely basis • Strict technical requirements for equipment to be used
Rational Unified Process (RUP)	<ul style="list-style-type: none"> • Attacks major risks early and continuously • Ensures the delivery of value to the customer • Accommodates change early in the project implementation • Builds systems with smaller components 	<ul style="list-style-type: none"> • Extensive documentation • For each project, the process must be designed • Insufficient for very complex systems 	<ul style="list-style-type: none"> • Fits most organisations, but most suitable for large organisations • Case driven, where development proceeds via a series of workflows • Reduces cost risks • Reduces risk of delayed product delivery 	<ul style="list-style-type: none"> • Least appropriate for very small organisation • Needs a great deal of documentation and consultation

Based on the comparison and analysis in Table 9, the most suitable system development method for OMREN will be customised between Spiral and Rapid Application Development. Spiral is good because it tends to break the project into smaller segments which enable evaluation throughout the lifecycle (See Figure 7). RAD can be considered as a good methodology because users are gaining more sense of ownership of a system, while developers are gaining more satisfaction from producing successful systems quickly. Moreover, for both methodologies, there is a possibility to determine the objectives, alternatives and constraints of each iteration and evaluate them to identify possible changes

and plan the next iteration. However, a more agile methodology is Rational Unified Process (RUP). It combines both the Spiral and RAD methodology to produce an agile and iterative way of development. This could be the best nominated methodology for OMREN.

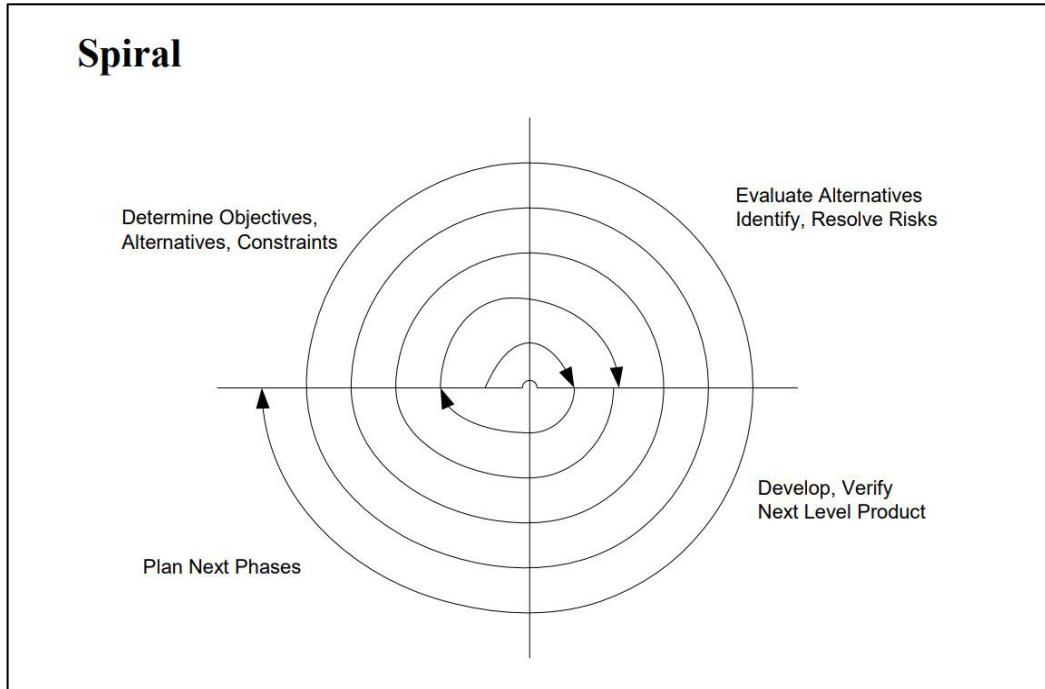


Figure 7: Spiral system development methodology

3.3.3 Guide Development of Solution Deployment

In this step, the deployment recommendations are set for each separate project or work package. This will help in guiding the development and deployment of each solution. The following procedures are very important to be implemented by OMREN management to achieve this step's goal:

- Document the scope of each project in a detailed manner which will make it clear for the developers and stakeholders.
- Document the strategic requirements which have been decided through the architectural perspective.
- Document the change requests as per the plan developed in phase E.

- Document the timeline requirements from the roadmaps created in Phases A to D of the developed EA (Al-Habsi, 2016).
- Guide the development of business and IT operating models for the proposed services.
- Document the Architecture Contract by obtaining signatures from all the sponsoring organisations such as TRC and TRA and the developing contractors such as the outsourced companies.

3.4 Phase H: Architecture Change Management

Phase H is intended to ensure that the Architecture lifecycle is maintained, and the architecture governance framework is executed. This ensures that the architecture capability meets the current requirements. OMREN should have the right procedures in effect for managing changes in the architecture. The main goal is to make sure that the architecture achieves the intended or target business value. It is possible that the implementation does not run as planned due to the new demands to modify the architecture. Therefore, there is a need for describing the change management process to maintain and apply changes to the architecture in a smooth and cohesive architected manner so that it achieves the changes without contradiction with the existing architecture.

As part of this phase and to achieve the above, it requires continuous monitoring of the change requests, new technologies or changes in the business environment. The steps in this phase must support the implemented EA as a dynamic environment that has the flexibility to evolve quickly as a response to the changes. It is critical at this level that the governance body sets up criteria to judge whether a change request is a simple architecture request for one or more of the phases, or it will require the setting up of a new cycle of the entire ADM.

There are three change request classifications. The first classification is the Simplification which is often driven by a requirement to reduce investment. The second classification is Incremental change driven by a requirement to achieve additional value from the existing services or investment. The last classification is re-architecting change, driven by a requirement to increase investments or services by creating a new value (Orbussoftware.com, 2018).

For OMREN to gain maximum benefit from the developed EA, it needs to perform a continuous evaluation of the implementation and get feedback from stakeholders to assess the

necessary modifications or new requirements. This should be approved by the senior management to be applied to the existing EA to confirm that all the changes relate directly to the business value of the organisation objectives.

3.4.1 Deploy Monitoring Tools

This section is considered as the most important among all the steps of Phase H. It is the first step in enabling the realisation of the value of the business and technology. OMREN implementation staff and senior management must utilise the benefit of monitoring the overall organisation in many aspects. The selected monitoring tools must ensure the ability to achieve the following:

- Monitor the technological changes which create an impact on the Baseline Architecture.
- Monitor the business changes which can create a positive effect on the Baseline Architecture.
- Track the Business Values. An example of this is the investment appraisal to determine the value metrics for the organisation's objectives.
- Monitor the Enterprise Architecture Capability maturity
- Monitor the continuity of business requirements.

There are many methods and commercial software products for monitoring projects but discussing specific products names is beyond the scope of this dissertation. For this EA, I will cover in detail the ways and techniques of project monitoring which could be useful to OMREN senior management and staff to monitor the implementation of the projects and work packages being developed at any time (European Commission, 2018).

Issue:

Effective monitoring needs allocating time and resources which could face some difficulty in OMREN due to the shortage of staff. Therefore, due to the importance of this step, it should be explicitly accounted for in each work package or project plan and budget.

Project Screening:

1. Gathering a list of all ongoing projects in the implementation phase with the basic information such as name, start/finish dates, responsible staff/manager and the financial status

2. Screen each project for a set of important related issues causes of not meeting the objectives if any and the delay reasons. This will help in assessing the risk issues and determining the risk level for each project.

The risk can be divided into four levels to help in deciding which project needs special attention and extra monitoring as the following (EuropeanCommission, 2018):

- **No Risk (1):** No clear risk in the project not delivering the planned objective or having delays.
- **Low Risk (2):** There is a low risk in delivering the project, but most of the issues have been identified and may require a follow-up.
- **Medium Risk (3):** the project is having some identified difficulties that will have a negative impact on the deliverable expected results and special follow-up is needed.
- **High Risk (4):** The project is having serious difficulties that have been identified, and the risk is very high that it will not deliver the expected results and needs significant follow-up.

Table 10 shows a proposal for a project Screening Table for OMREN projects. The table can be used by OMREN management to determine the relative risk rating. It will cover some general issues that face IT projects such as the complexity of the project, the level of other social risks, the overall business value of the project and the last one is funding.

There are more specific performance issues that have more impact on the project. The table includes some examples of the expected issues based on my understanding of OMREN. Below is a brief explanation of some possible issues that could face IT projects and should be considered by OMREN (EuropeanCommission, 2018):

- **Technical difficulty for implementation** can cause delays to the submission and may also affect the scope of the project.
- **Critical employee quits** can cause serious disruption to the ongoing execution of the project tasks.

- **Change in scope** is also frequent in IT projects. Regardless of the requirements specifications, there are also changes and suggestions that come from the stakeholders or sometimes from the developers.
- **No problems reported:** the top management should be aware of the importance of this point. It might be true that no problems are reported and everything is calm, but it is very rare especially in IT projects. Hence, the management should be worried about this and should take some measures and investigations to confirm that everything is going perfectly and according to schedule.
- **Becoming behind schedule** there exist some unforeseen technical difficulties or sometimes a change in the scope which could turn the project upside down and cause some delay on the due date.
- **Contractor problems or withdrawal:** This is an important point to be always accounted for because it is also unforeseen by the stakeholders. Therefore, when outsourcing projects, OMREN should always be prepared with backup plans or other companies to take over the implementation of the projects (Stoy, 2018).

Table 10: Project screening proposal for OMREN project follow-up

Project Name:		
Start:	Due:	
Date of Assessment:		
Project Manager:		
General Issues	Risk Rating (1, 2, 3, 4)	Notes/suggestions/issues for follow up
Complexity of the project		
Level of environmental or social risk		
Overall business value		
Funding		
Performance Issues:	Risk Rating (1, 2, 3, 4)	Notes/suggestions/issues for follow up
Technical difficulty for implementation		
Critical employee leave		
Change in scope		
Becoming behind schedule		
Contractor problems		
No problems reported		

The issues shown in Table 10, above, are based on some examples from specialist IT management organisations (Stoy, 2018), (European Commission, 2018). They are examples of some of the issues that usually face projects especially the ones related to IT. OMREN staff and management can extend the table as per their vision to the implementation phase and may modify these issues based on the status and upcoming updated in each project. Different projects may have different issues. However, there are some common risks in IT projects which are mostly covered in Table 10. Being aware of these risks could help in preventing them if they are spotted earlier which can save the project from failure.

3.4.2 Manage Enterprise Architecture (EA) Risks

This section is mainly concerned with managing the EA risks and making recommendations for the IT strategy. Originally, part of the EA is meant to be focus on reducing the risks for the organisation. Nevertheless, the EA itself could face some risks that may have a negative impact on adopting it across the enterprise. The continuous iterative nature of the EA approach creates further complications in identifying and managing the risks. For example, unforeseen effects may result from EA processes or may be linked to any of the levels of EA projects in any of the phases (Niemi and Ylimäki, 2007).

In this section, I will discuss some of the common EA risks that OMREN should be aware of, in order to avoid them. For OMREN practitioners, this can provide a list of risks associated with the developed EA. It can be used as a checklist in risk identification to confirm the risk management precautions and practices are planned.

The risks are concluded in the following points from the author's point of view. This list could be later modified by OMREN practitioners and management staff who are responsible for implementing the EA which will be more accurate based on their experience (Mar, 2016), (Niemi and Ylimäki, 2007):

- 1. Increasing Solution Costs:** Over-engineering is always a drawback of EA programs. Enterprise architects present their solutions and frameworks which they think can provide architectural benefits such as scalability and usability. However, this could sometimes be costly for the organisation and may be difficult for the business targets that they were designed for.

Recommendation: OMREN financial status is unlikely to face this risk since it is funded by the TRC and it is considered a major project which needs to complete as planned. However, the senior management should create and implement a proper budget plan in accordance with the developed EA.

- 2. Decreasing User Acceptance:** Any new system or methodology faces some unacceptance from the employees and customers. EA introduces common solutions which are seen by some employees to be less beneficial to the presented services compared to their Silo-solutions.

Recommendation: OMREN should focus on preparing its departments and staff with the required awareness about the benefits of EA to the overall organisation, regardless of their individual department or personal point of view.

3. Creating Dependencies: EA is a common solution can create new dependencies between projects or services. For instance, some projects have different business cycles and may require or depend on some other projects. Another example is the change request that may conflict with other projects and cause a lack of agreement on the planned roadmap which could affect the whole implementation plan.

Recommendation: This is more likely to happen in most IT projects within the organisation. OMREN should take this into consideration from the beginning in order to avoid any dependencies or alternatively there should be an agreement on solutions between different projects or work packages.

4. Measure the EA Performance Carefully: Applying an EA framework to an organisation often introduces performance metrics. When these metrics are used to evaluate projects and teams, they are sometimes counter-productive results. Staff tend to change their behaviour when they know they are evaluated by metrics. For example, if a department is under-budget, the manager will try to engage wasteful spending to conform to target. Another example, if an employee is required to achieve some target in software developing, he/she could delay the process initially and work faster by the end to achieve the target.

Recommendation: Metrics are a good way of measuring performance which can be applied by OMREN, but the top-management should be careful about when and where to use them and should also have accurate plans for the projects and the targets to be achieved in accordance with the budget available.

5. Distracting Critical Staff: Internal stakeholders are always complaining about the EA being cumbersome. Training, reviews and meetings could distract some of the important staff from their main responsibilities.

Recommendation: OMREN applying of the EA should be focused, and it should assign responsibilities to specific staff to cover the part of keeping the status of the projects and implementing the framework smoothly to prevent wasting resources.

6. Security Vulnerabilities and Exposures: Applying an EA to the organisation should provide common security issues. However, EA practitioners are rare to be security experts, in practice, and this could make things worse to face some security risks.

Recommendation: For OMREN to be able to create a safer environment, it should contract a security specialist to build a solid plan against vulnerabilities and exposures.

7. Poor Alignment between the Organisational Objectives and EA: This could happen due to an unclear or missing image of the EA and the insufficient control of the effects expected from the strategy change which leads to an ineffective work system performance.

Recommendation: OMREN should draw a clear picture of the EA from the beginning of the project which helps in clarifying all the roles and expectations from all the related units and departments of the organisation.

There are many risks related to adapting and applying an EA in the organisation. The risks discussed above are some of them which the author thinks are related to OMREN's project. To have a full risk assessment that is potentially related to applying the EA, architects and practitioners from within OMREN should carry out a thorough study which will cover all the possible risks that might face an EA before applying it. Consequently, it will be safe to adopt the EA and prevent unsuccessful implementation which can cause serious negative effects on the organisation (Niemi and Ylimäki, 2007).

3.5 Architecture Governance Using COBIT 5 Framework

3.5.1 Introduction of Enterprise Architecture (EA) Governance:

After completing the development of all the phases of the EA, arises an important part which is the EA governance. The main purpose of EA governance is to make sure that the organisation's investments are aligned with the overall objectives. Moreover, it must confirm that IT investments are meeting with the business goals and processes. This can be achieved by allocating the IT resources to the projects with the highest impact on the organisational efficiency (Brooks, 2009).

While the most important role of an EA is the improving the IT investments, the EA itself needs to be governed as well. Any incorrect design in the EA could cause a wrong investment on IT systems that could adversely have a negative impact overall the organisation. Brooks

argues that the EA governance focuses on two primary objectives: the first one is ensuring that the EA is properly planned and managed to produce the expected artefacts and the second objective is to ensure that the IT investment decisions are always aligned with the organisation goals through the ideal implementation of the EA (Brooks, 2009).

The EA governance processes start as simple guidance tools, but over time they become more complex and cumbersome. Therefore, the organisation should be aware of the main purpose that these processes were initially meant to achieve. This can be ensured by confirming some of the important basics of EA governance to make sure that IT projects have an efficient architecture that supports the business (Mar, 2012). These basics are illustrated by nine important points in Figure 8.

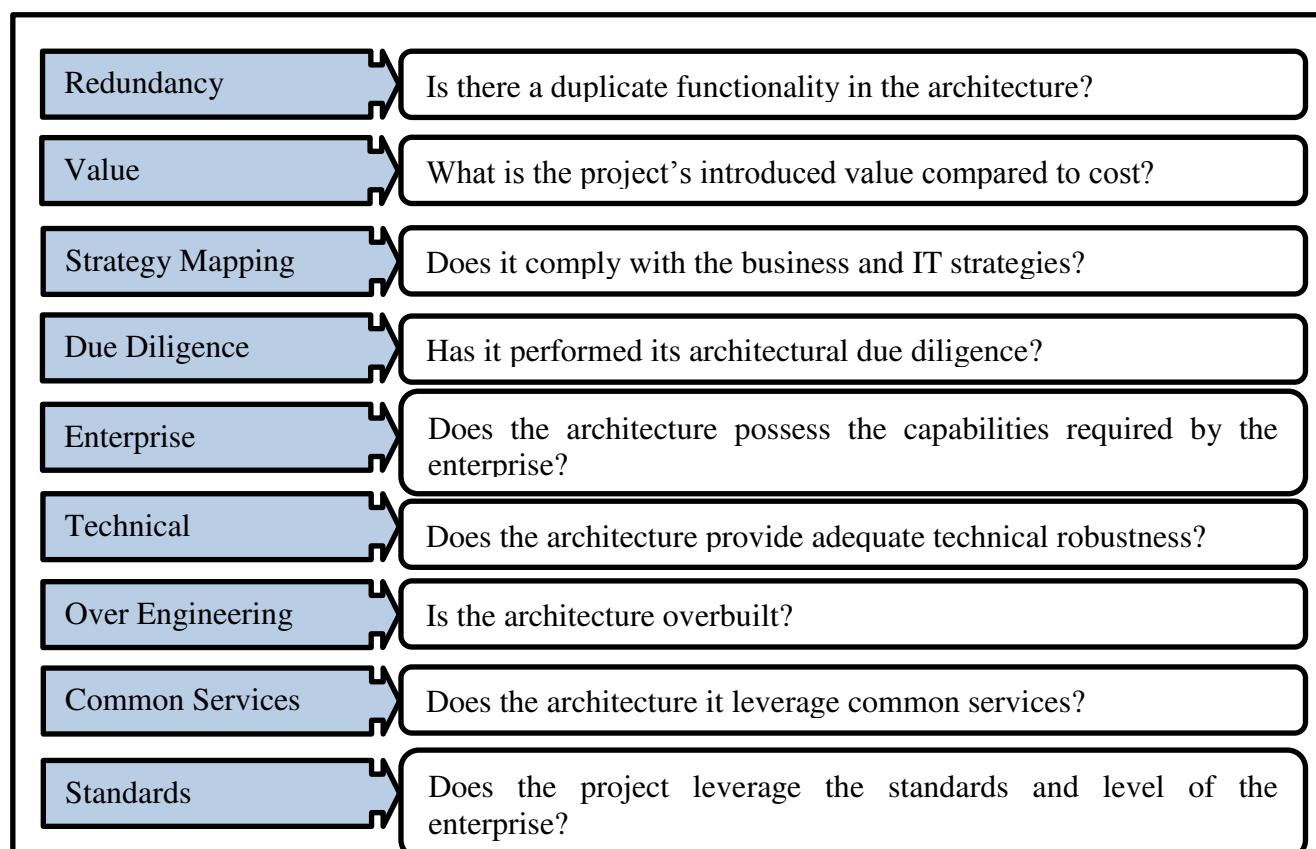


Figure 8: The basic 9-point check to confirm that the EA governance will get you more than half the way there (Source: Mar, 2012)

3.5.2 Key Concepts:

Architecture governance is a methodology that is created on certain key concepts to build the conceptual structure of the EA (The Open Group Architecture Forum, 2018). Figure 9 illustrates the main concept based on business, technology and regulatory context.

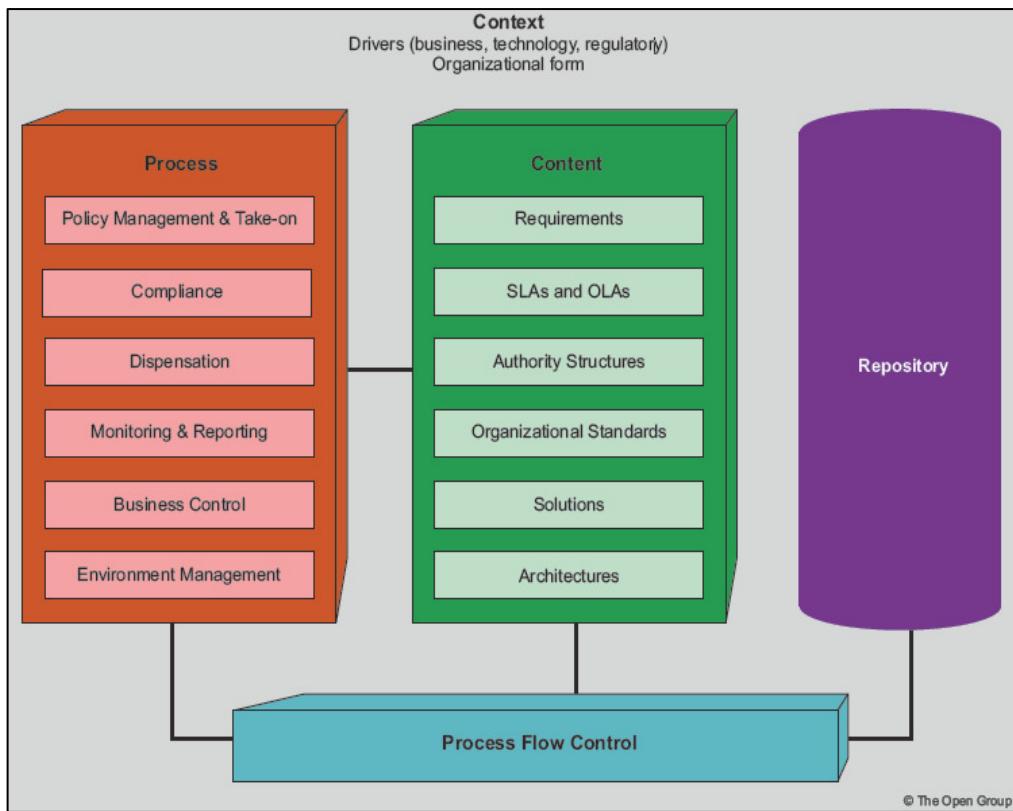


Figure 9: Architecture governance framework - conceptual structure (The Open Group Architecture Forum, 2018)

3.5.3 Applying EA Governance:

The EA is governed through assigning some advisors or managers in the strategically critical projects. These advisors are governed by the main Corporate Governance. Typically, they will act as the architects of the EA to guide the projects successfully towards the Target Architecture. The leading advisors in the case of OMREN could be the project managers who will work with the goal of ensuring the alignment and integrity of all the parts of the organisation. The architecture work from the leading advisors is very significant and critical in maintaining the EA (Parmo, 2009).

3.5.4 Levels of Governance within the Enterprise:

According to TOGAF, the Architecture Governance is the act of guidance by which the EA is managed and controlled all over the enterprise. EA Governance usually does not operate in isolation, but within a hierarchy following the organisation's domains which are: Corporate Governance, Technology Governance, IT Governance and Architecture Governance. Each of these domains may exist as governances of many geographic levels. However, the Corporate

Governance is beyond the scope of this project, so it will not be covered. This section aims to focus on the following (The Open Group Architecture Forum, 2018):

- Provide an overview of the nature of the governance as a discipline.
- Describe the context of the governance which operates within the enterprise.
- Describe the architecture governance framework that can be applied in practice for the EA and IT architecture.

3.5.5 Nature and Characteristics of Governance:

The EA governance is mainly about ensuring that the business processes are done perfectly. This means it is not meant to be for controlling the rules with strict adherence. Therefore, it is guiding the organisation towards an effective usage of the resources. The general concept of the governance is to focus on the rights, roles of the shareholders. Moreover, it ensures strategic guidance of the organisation and confirms effective monitoring of the management.

On the other hand, the main characteristics of the governance are elaborated on the values and necessity of the governance as an approach and its importance to be adopted in the enterprise to organise the dealing between all the parties. Figure 10 shows the main characteristics of the governance with a brief description of the benefit of each one.

Discipline	Transparency	Independence	Accountability	Responsibility	Fairness
<ul style="list-style-type: none"> • All parties involved will have a commitment to procedures, processes, and authority structures established by the organisation. 	<ul style="list-style-type: none"> • All actions implemented and their support for decision-making will be available for inspection by authorised organisations and provider parties. 	<ul style="list-style-type: none"> • All processes, decision-making, and mechanisms used will be established so as to minimise or avoid potential conflicts of interest. 	<ul style="list-style-type: none"> • Identifiable groups within the organisation — e.g. governance boards who take action or make decisions are authorised and accountable for their actions. 	<ul style="list-style-type: none"> • Each contracted party is required to act responsibly towards the organisation and its stakeholders. 	<ul style="list-style-type: none"> • All decisions taken, processes used, and their implementation will not be allowed to create unfair advantages for any one particular party.

Figure 10: Characteristics of governance according to TOGAF (Naidoo, 2002)

3.5.6 Technology Governance:

Technology governance is responsible for the utilisation of the organisation's technology capabilities for development, research and improvement of its services. Some of the technology governance models may include the IT governance activities, but it usually has a

wider scope. Technology governance is a major requirement, capability and resource for most organisations because of the widespread of technical aspects in this era. Nowadays, business is more dependent on IT in most of the organisations. This implied some sort of balancing between intangibles and tangibles for providing the necessary management level; knowing that most of the intangibles are informational and digital assets will bring the IT governance under the technology governance.

Taking the case of OMREN, and from analysing and studying all the services and products introduced, it is obvious that the business depends on information, processes, systems and network. All of them together as a whole system to deliver the required services to the customers. All the universities, colleges and local education organisations that agree to benefit from OMREN as a national research and education network will create more load on the technology governance due to the dependency on both tangible requirements such as the physical network and intangible benefits such as the link to international research centres (The Open Group Architecture Forum, 2018).

3.5.7 IT Governance:

IT governance is one of the powerful ways to enhance the level of the of Information Systems processes in the organisation. There are many IT governance methods based on numerous frameworks. The concept of IT governance enables information systems to be audited and controlled to be consistent with the original plan set by the organisation's strategy. The IT governance assists the management in integrating IT, resources and implement the organisation's IT strategy according to the requirements of the business development. However, there is a bridge between the IT and the business strategy. This bridge can be built through the EA (Geng, Niu and Li, 2014).

The IT governance has become an essential part of an effective and successful modern organisation. Businesses depend on IT to gain a competitive advantage for managing the complex technology requirements in the organisation to leverage its key resources. According to TOGAF, the IT governance sheds light on the regulatory environments to enforce a better enterprise control of information and information systems. Applying an appropriate strategy together with an IT governance implemented by the top management clarifies who owns the enterprise resources and who has the maximum responsibility of integrating each enterprise asset with the information systems (The Open Group Architecture Forum, 2018).

3.5.8 IT Governance Framework (COBIT 5):

TOGAF recommends the Control Objectives for Information and related Technology (COBIT) as a good IT governance framework. It provides an adequate detailed source of information on the governance of the IT. COBIT is an open standard developed by the IT Governance Institute (ITGI) that enables controlling and providing useful tools and methodologies to achieve a good IT compliance with the strategy of the organisation. The latest version of this framework is COBIT 5.

3.5.9 Applying COBIT 5 Framework for OMREN:

COBIT 5 helps enterprises create optimal value from IT by maintaining a balance between realising benefits and optimising risk levels and resource use. COBIT 5 enables information and related technology to be governed and managed in a holistic manner. The principles and enablers of COBIT 5 are generic, and most of them are generally applicable. A series of publications, education and online collaboration will drive the COBIT Framework forward.

COBIT 5 Framework is built upon five basic principles which contain enablers for the management and guidance of an enterprise IT (See Figure 11). It proved itself as a way of planning, supporting, managing and updating the IT solutions in the organisation internally. Moreover, it is applied to introduce a quality service to external customers (Marciano, 2015). COBIT 5 provides a comprehensive framework designed to help any enterprise achieve its objectives both governance and management. It enables the IT to be governed and managed in a comprehensive way through the enterprise.

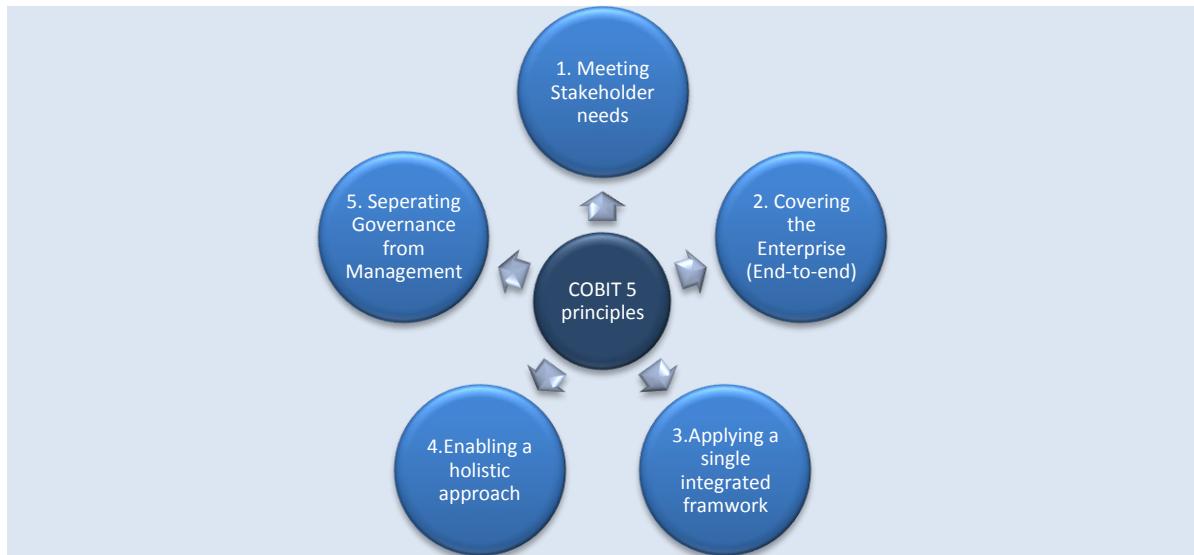


Figure 11: COBIT 5 Principles (COBIT 5, 2012)

3.5.9.1 Principle 1: Meeting Stakeholders' Needs:

The main reason for any organisation's existence is to create value for the stakeholders. As a result, any organisation will be creating value as a governance objective. Creating value means creating benefits with the minimum costs and risks. Benefits have many forms such as financial benefits in the private sector. However, in the case of OMREN, the benefits are in the form of public service for the whole country and especially for the research and education community. Figure 12 shows how is the value creation is driven by the stakeholder needs.

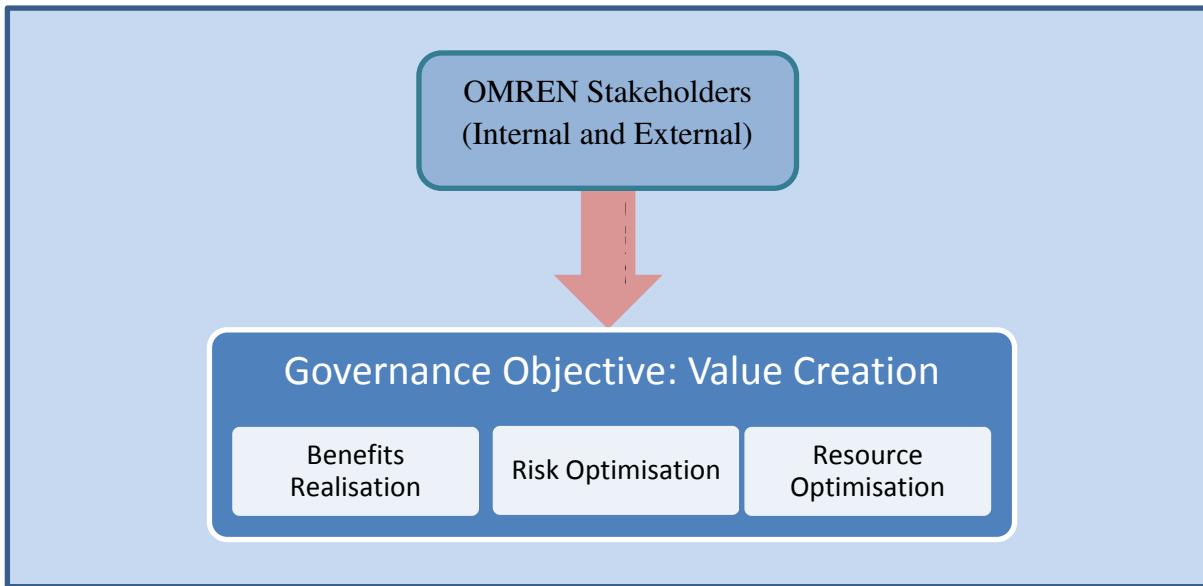


Figure 12: The governance objective - value creation

OMREN works in a specific context and goal determined by many internal stakeholders such as the TRC and sometimes external stakeholders such as universities and colleges which requires a customised governance and management system. The **goals cascade** is the nerve centre of COBIT 5. It helps in identifying the stakeholder needs and the organisation objectives by achieving the technical outcomes that support the successful implementation of the projects in the organizational structure. Overall, COBIT 5 helps the senior management understand the business needs in terms of information systems which conforms aligning the IT initiatives with the business requirements before planning, organizing and building any system (Zororo, 2015).

OMREN senior management and stakeholders should agree on the information systems requirements and the priorities of the systems and software developments before acquiring them. The picture should be clear about all the business drivers, requirements and suggestion of all the joint universities and colleges in addition to the TRC by means of an agreement or a memorandum of understanding. These steps could save OMREN from wasting budget in systems that cause poor utilization of the IT-enabled investments. Therefore, new initiatives for IT investments should always be relegated to IT and business top management. Furthermore, the governance should state that these two parties are committed to the decision making and should always participate in it.

Using goals cascade from COBIT 5 management will help to align, plan and organise (APO) the calls for enterprise management activities to be aligned to stakeholder needs and organisation objectives. Moreover, after identifying the business needs, the Return on Investment must be figured out. In OMREN, there are tangible benefits such as subscription fees gained from universities and colleges. Moreover, there are intangible benefits such as the popularity and the good reputation of being a reliable NREN in the country. Figure 13 illustrates the basic model of the goals cascade for the OMREN project.

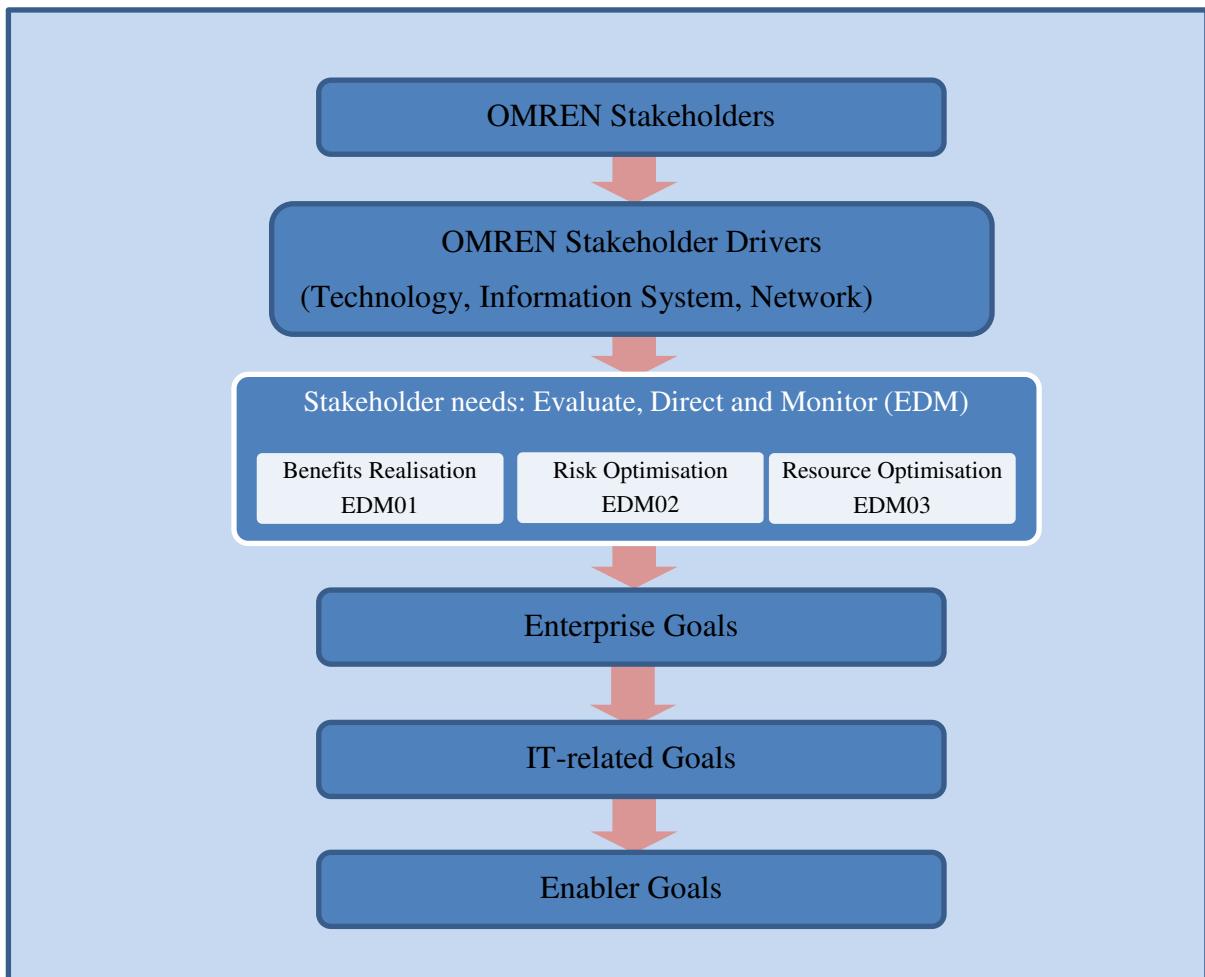


Figure 13: The COBIT 5 goals cascade for OMREN (COBIT 5, 2012)

Example: Creating the Goals Cascade to the OMREN's e-Library Service:

This is an example of building the goals cascade for the **e-Library** service. The external stakeholder is the research community in Oman (universities, colleges, etc.). The stakeholders' main **drivers** are focused on establishing a high-speed network to OMREN and obtaining a trusted source of information for their research purposes.

Out of the 17 **enterprise goals** defined by COBIT 5 (See Appendix A), the two drivers above raise the following goals according to the BSC (Business Scorecard) dimensions and by setting the level of relationship between ‘P’ (Primary) or ‘S’ (Secondary) (see Table 11):

- 01 Stakeholder value of business investments
- 07 Business service continuity and availability
- 08 Agile responses to a changing business environment
- 10 Optimisation of service delivery costs
- 14 Operational and staff productivity
- 16 Skilled and motivated people.

Table 11: Customised enterprise goals for the e-library service

BSC Dimension	Enterprise Goal	Relationship to Governance Objectives		
		Benefits Realisation	Risk Optimisation	Resource Optimisation
Financial	01 Stakeholder value of business investments	P		S
Customer	07 Business service continuity and availability		P	
	08 Agile responses to a changing business environment	P		S
Internal	14 Operational and staff productivity	P		P
Learning and Growth	16 Skilled and motivated people	S	P	P

After setting the enterprise goals, we analyse the corresponding **IT-related goals**, which are listed as follows:

- 01 Alignment of IT and business strategy
- 07 Delivery of IT services in line with business requirements
- 09 IT agility
- 11 Optimising IT assets, resources and capabilities
- 17 Knowledge, expertise and initiatives for business innovation
-

Table 12: Customised IT-related goals for the e-library service

IT BSC Dimension	Information and Related Technology Goal	
Financial	01	Alignment of IT and business strategy
Customer	07	Delivery of IT services in line with business requirements
Internal	09	IT agility
	11	Optimising IT assets, resources and capabilities
Learning and Growth	17	Knowledge, expertise and initiatives for business innovation

IT-related goals lead us to the final step in the goals cascade, which is the **Enabler Goals**.

The enablers of the e-Library service can be seen under the following categories:

- **Application:** Creating a website portal with a single sign-on for all the members to reach the required information through the e-Library service.
- **Connectivity:** Build the network to connect all the members through the local service providers and partners
- **Information:** The agreements with other NRENs around the world provide the information needed for this service
- **People:** OMREN's skilled staff who will participate in achieving the goals with the agility approach.
- **Infrastructure:** The use of the existing Data Centre to accommodate all the information and applications.

Analysing these enablers, we can see that some of them are dependent on the other. For instance, the Information and Application enablers depend on the People and Infrastructure enablers. All these enablers are driven by the It-related goals. The availability of these enablers will help OMREN achieving the e-Library service.

e-Library Service (Goals Cascade)

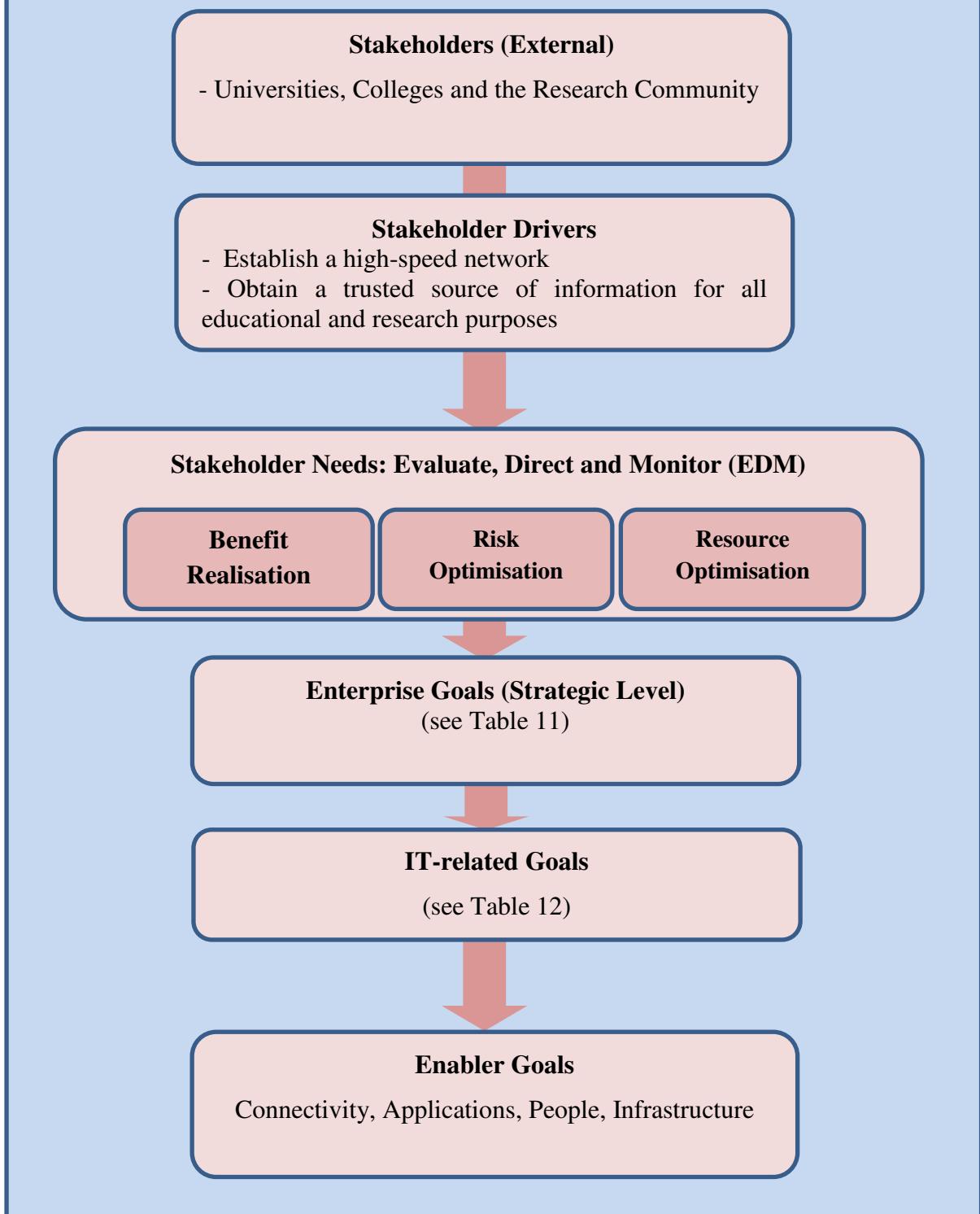


Figure 14: OMREN's e-library service goals cascade)

Principle 2: Covering the Enterprise End-to-end:

All the Information systems and technology in OMREN should be addressed by the governance and management and must be covered by IT (See Figure 15). According to COBIT 5, this is addressed by integrating the IT governance into the enterprise governance. Moreover, all the processes and functions to govern the information and related technology are also included. consequently, the enterprise will be covered as an end-to-end which comply with the governance approach of COBIT 5.

The end-to-end approach contains four main points: the governance objectives to create values (done in principle 1), the enablers which are the factors that determine if a certain project or process will work perfectly, the scope which is how much of the organisation will be covered and finally the roles, activities and relationships. COBIT 5 deals with information and related technologies as assets that require attention like any other asset in the organisation.

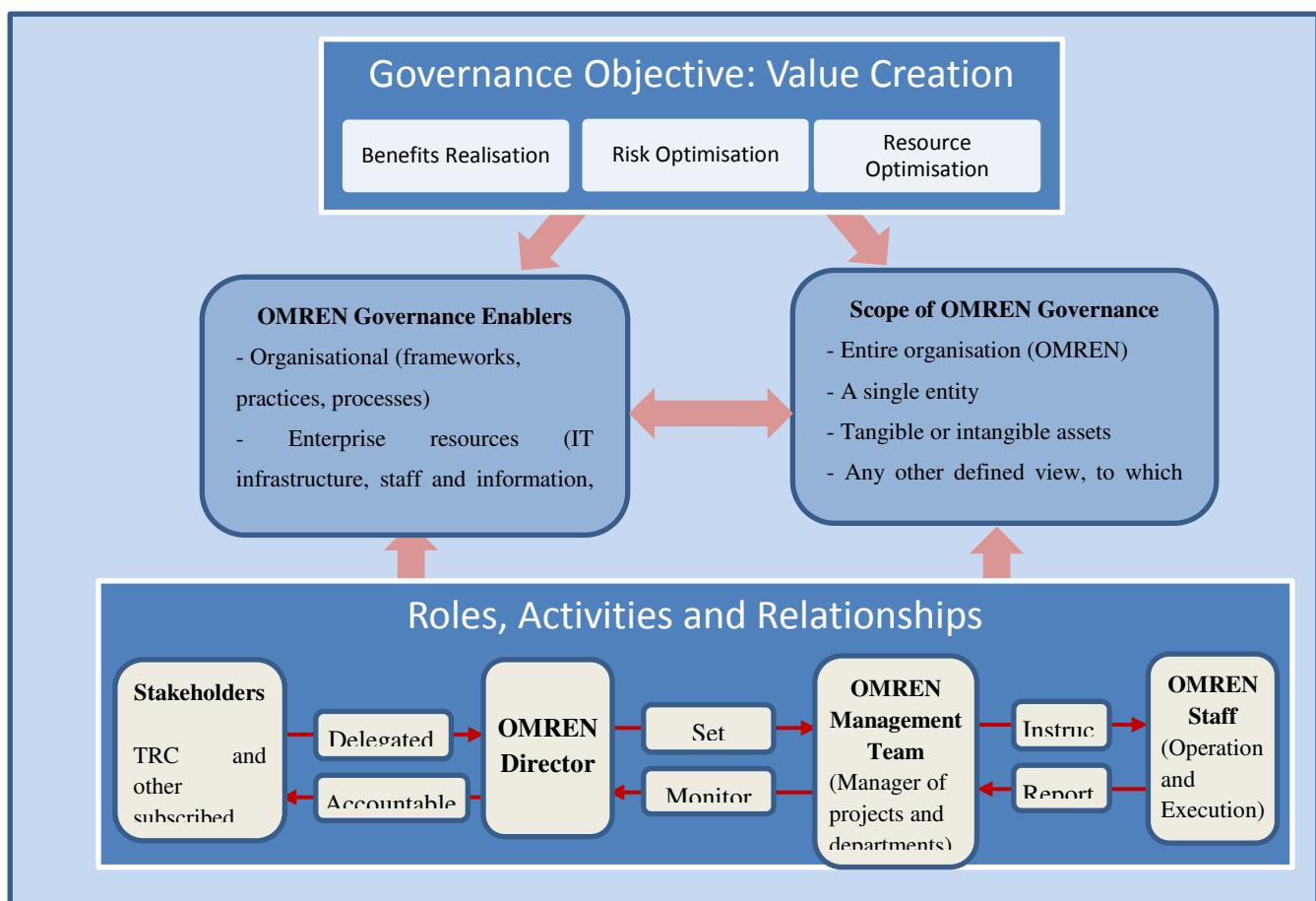


Figure 15: OMREN governance and management Using COBIT 5

OMREN's business executives need to identify the drivers of the business and justify why the enterprise will spend the budget on a particular investment. The justification must be linked to specific enterprise strategic requirements (Zororo, 2015). In the case of OMREN, the driver is building and providing a high-speed network with all the services specified in the Phase 1 Architecture Vision in the developed EA (Al-Habsi, 2016) to serve the higher education and research community in Oman. Once the business needs are specified with the IT enablers, the benefit should be clearly identified which is introducing a national research and education network for the country. This benefit is compared to the cost in order to establish a cost-benefit clear picture. The last part is to decide the length of the strategic plan which is usually a five-year plan (Desai, 2016). A Five-year plan can align the resources and capacity of OMREN to the overall implementation plan to achieve the objective of the vision. This can create a good guide for the budget utilization over the time span and can easily cope with the priorities of OMREN. Lastly, the overall services are enabled by IT projects and their performance which should be directly focused on enabling OMREN to deliver the stakeholder needs.

3.5.9.2 Principle 3: Applying a Single Integrated Framework:

Any organisation always has a challenge of the management and governance of its Information and technology. This is due to the continuous requests internally and externally to obtain the required changes in terms of IT. Considering these points, arises the need for a framework to provide coverage and consistency to the organisation with keeping in mind some flexibility and room for customization (COBIT 5, 2012). There are four reasons that positioned COBIT 5 as an appropriate and reliable framework for the organisation. Firstly, it takes the latest standards and frameworks into account which helps align governance with other organisation activities. Secondly, it is an integrated source of guidance in non-technical easy language. Thirdly, it can be easily integrated with other frameworks such as TOGAF, ITIL and ISO. Lastly, it offers a complete source of IT governance and management best practices (Orbussoftware.com, 2018).

3.5.9.3 Principle 4: Enabling a Holistic Approach:

Enablers:

The Powerful management and effective governance of the IT across the organisation needs considering many components. Gathering as much information as possible is essential when

it comes to making decisions in the organisation. This means that we must have a comprehensive overview of the organisation which is in this context related to the management processes and structures. COBIT 5 defines a set of enablers to support the implementation of the required governance and management system. These enablers are part of the organisation's main roles and objectives. They can be figured out by defining the factors that individually and collectively influence the success. Moreover, these enablers are also driven by the goals cascade implemented in principle 1. The enablers are described in seven categories which are shown in figure 16.

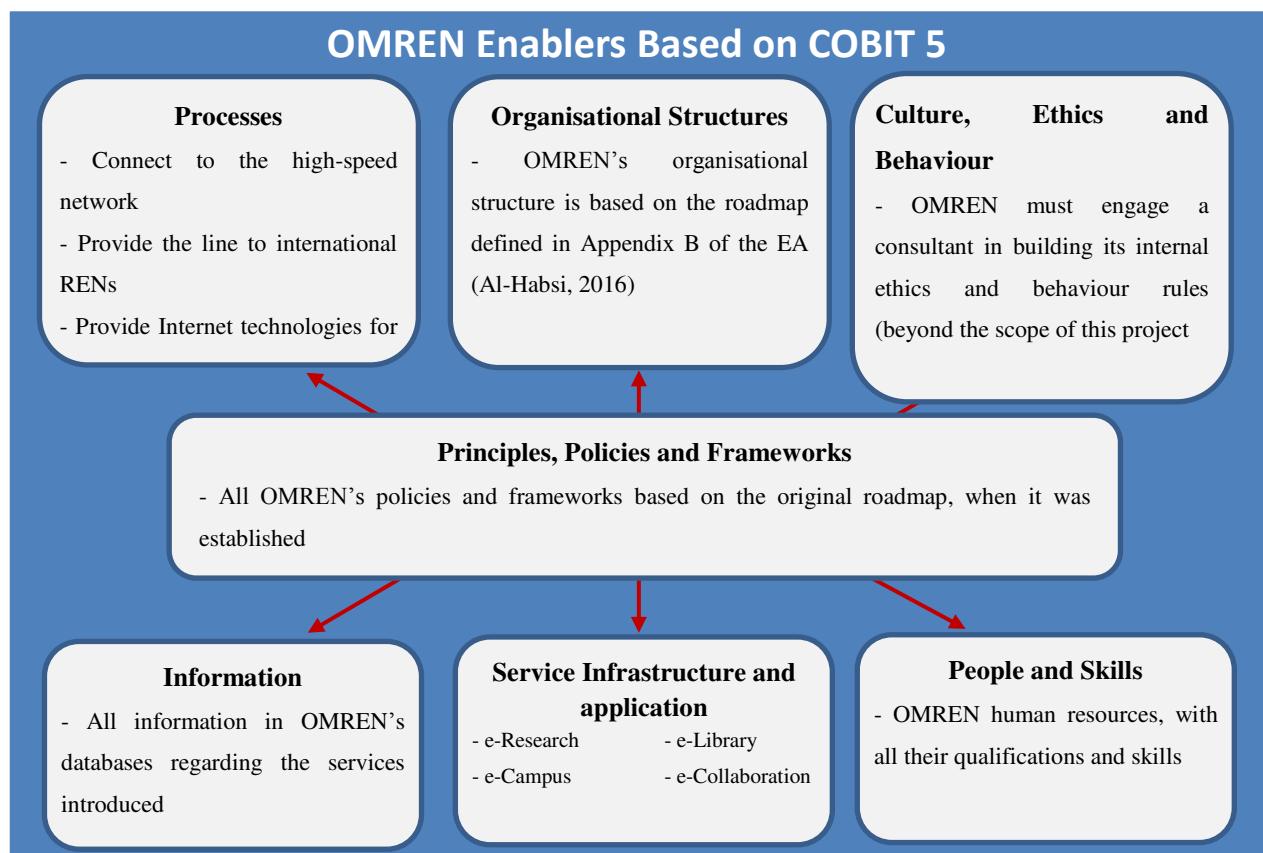


Figure 16: OMREN enablers based on COBIT 5

Enabler Dimensions:

According to COBIT 5, all enablers of an organisation have a set of common dimensions. These dimensions provide a common and simple way to deal with the enablers. Moreover, they allow each unit in the organisation to manage the complicated interaction and create a successful outcome for the enablers. The enabler dimensions can be summarised into the

following four main categories which are also illustrated in Figure 16 (Simplilearn.com, 2018):

1. Stakeholders:

Any internal and external stakeholders related to OMREN who play a specific role as an enabler. This will include the TRC, top management and all the staff. In addition, the outsourcing companies (e.g. Omantel) are considered as a stakeholder or an enabler for the network. The main external stakeholder is ‘customers’, which are universities and colleges and researchers. Stakeholders’ requirements are translated into the IT-related goals of the organisation.

2. Goals:

Each of the seven enablers defined in Figure 16 is responsible for a number of goals. The goals can be any expected outcomes of the enabler itself, or it can be an application or an operation of the enabler. Going back to Figure 13, we notice that the enabler goals are the last step in the goals cascade.

3. Life Cycle:

Each enabler has a life cycle which starts with the inception and goes through the operational life until it ends with the disposal. This is applicable to information, processes, structures and policies. The lifecycle consists of many phases:

- Plan
- Design
- Build or implement
- Use or operate
- Evaluate or monitor
- Update or dispose

4. Good Practices:

Good practices can be defined for each of the enablers to support the enabler goals. Good practices provide examples and suggestion on how to implement a certain enabler successfully. Moreover, it shows what works best for a product in terms of an input and an output.

For OMREN to get use of its enablers according to COBIT 5 Framework, each of these enablers must go comprehensively through the enabler dimensions and use some metrics to

measure the performance of each one. For example, the infrastructure and application enablers consist of many services provided by OMREN as the only NREN in Oman. Each of these services must go through the four enabler dimensions to perform the necessary evaluation properly, which measures the metrics for each dimension. To measure all the processes and services accurately, OMREN management should answer the questions of the enabler performance management shown in Figure 17 for each service and product, and even for the daily processes implemented by the staff across the organisation with special attention to the IT related services. Typically, this is due to the technical nature of the services provided by OMREN.

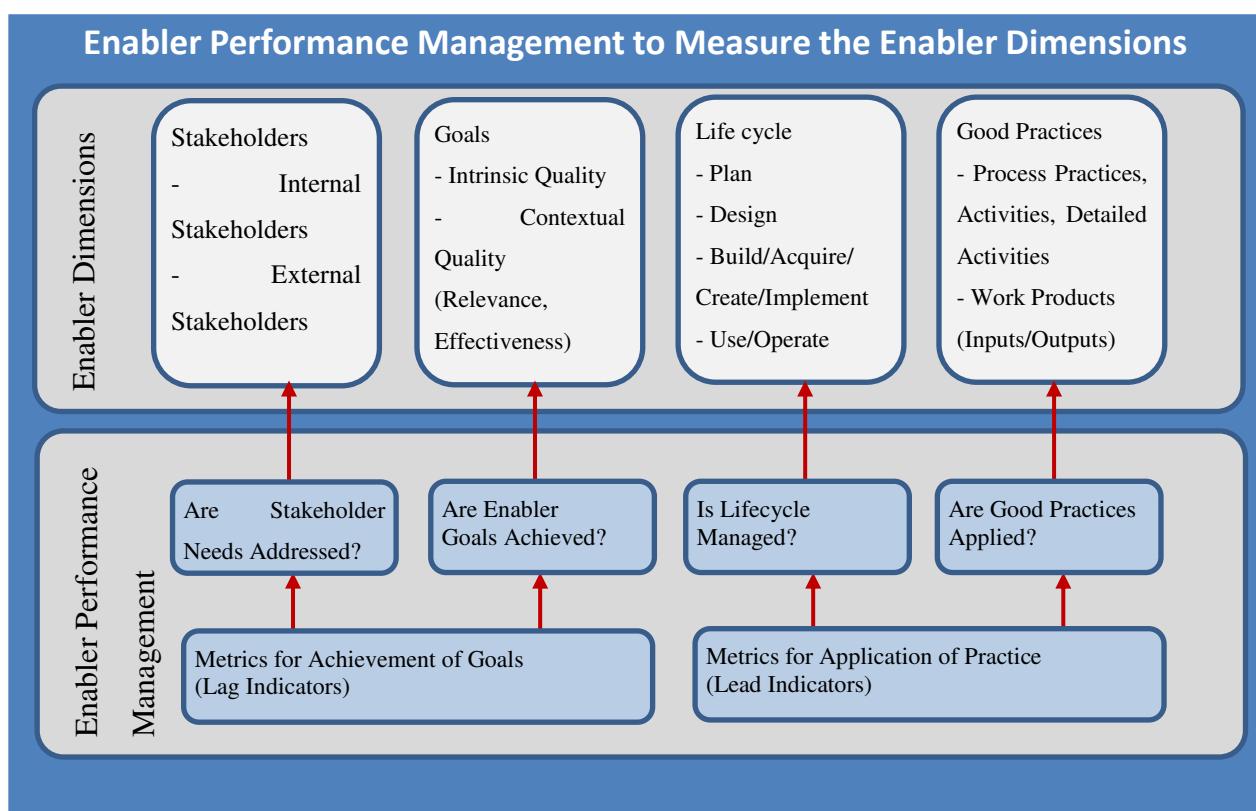


Figure 17: Enabler performance management to measure enabler dimensions

3.5.9.4 Principle 5: Separating Governance from Management:

This is the final COBIT 5 principle. It explains how the framework makes a clear distinction between governance and management. These two concepts originally serve a different objective. Each one includes different types of activities which involves different organisational structures (Khanyile and Abdullah, 2013). Governance role is to make sure that stakeholder needs, conditions and options are evaluated to confirm achieving balanced

and agreed enterprise objectives. Moreover, it determines the right direction by setting the prioritisation and making the right decision at the right time. Governance is also concerned with monitoring performance and compliance of the agreed-on objectives. In most enterprises, governance is the responsibility of the board of directors under the leadership of the chairperson. In the Case of OMREN, we can consider the chairman of TRC as the chairperson of the organisational structure.

On the other hand, a management plan is about running and monitoring activities and aligning them with the direction set by the governance body to achieve the enterprise objectives. In most enterprises, management is the responsibility of the executive management under the leadership of the Chief Executive Officer (CEO). In this case, the Director of OMREN is the CEO and head of the management team. The rest of the managers in the organisational structure such as the Infrastructure manager, the Telecommunication manager and the Applications manager in addition to other administration managers are representing the management team.

OMREN can organise its processes the way it suits their needs considering all governance and management objectives are covered. COBIT 5 includes a process reference model which can be used by OMREN to create the details of the governance and management processes. It covers most of the processes of any enterprise from the IT aspects and perspectives providing a common reference model which can be understood by both the IT staff and the managers. COBIT 5 Process Reference Model is a comprehensive model which includes a set of 37 governance and management processes (see Appendix A). Discussing all these processes is beyond the scope of this project. However, OMREN management should study the reference model from COBIT 5 and accordingly define its own set of processes considering its own situation and needs to build the most suitable reference model.

3.5.9.5 RACI Chart:

COBIT 5 recommends one of the important concepts in the field of management and governance which is (RACI) chart. It stands for Responsible, Accountable, Consulted and Informed. RACI chart is a matrix that is used to clarify the roles and responsibilities of an ongoing project or process. It makes sure that nothing is missing while implementing processes. Moreover, it helps in preventing confusion by assigning clear ownership of tasks and decisions (Racichart.org, 2018). OMREN management and project managers should

create a RACI chart for each project. This step will be a very efficient way to identify all the details of projects or processes in terms of who is responsible for what, and to what extent that responsibility is based on the four categories defined above. Figure 17 shows a sample RACI matrix that can be later modified by OMREN's management to create a special RACI chart for each of project. The RACI model basic elements are the following (Racichart.org, 2018):

Job Functions or Titles: (e.g. IT, HR, Project Manager, Finance, etc.) are placed across the top of the matrix.

Tasks and Responsibilities: (e.g. Developer, Network, system Admin, security, Database, etc.) are placed to the left of the matrix vertically.

R (Responsible): all the personnel who perform the work. There must be one 'R' in each row.

A (Accountable): The person who is accountable for the work or decision being made. There can be from zero to one 'A's' in each row, but no more than one.

C (Consulted): Anyone who must be consulted with prior to a decision being made and/or the task being completed. There can be as many 'C's' as appropriate in each row.

I (Informed): Anyone who must be informed when a decision is made, or work is completed. There can be as many 'I's' as appropriate in each row.

Process Name: Description of the process or project

Created on: Date of creation

Created By: (Names of all personnel working on this project)

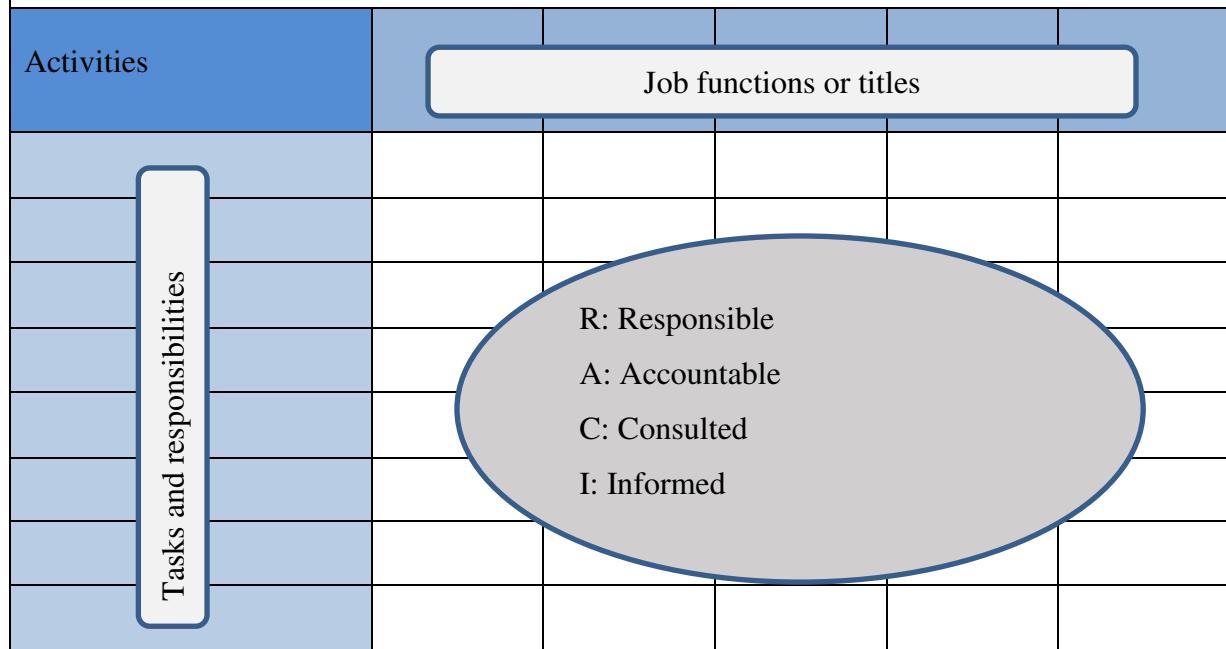


Figure 18: RACI template proposal for OMREN (Racichart.org, 2018)

Chapter 4 –Reflection and Evaluation

This chapter will discuss and evaluate the developed EA and governance frameworks. The discussion will focus on the research objectives and scope, while also evaluating the completed work and its usefulness to OMREN.

4.1 Procedure for the Methodology

The procedure for the methodology consisted of collecting all necessary information about OMREN from the OMREN website and from an older dissertation project for developing EA, executed by Al-Habsi (2016). These two sources fed the case study with the information required to complete the ADM Phases of the developed EA. The EA developed by Al-Habsi (Phases A to D) provided sufficient information about the basic requirements for building the pending ADM Phases (Phases E to H). The same applied to the governance frameworks, where all the required information on OMREN's services and processes were derived from the same source (Al-Habsi, 2016). Building the EA relied mostly on the TOGAF Framework, whereas building the EA governance and IT governance sections relied on both the TOGAF and COBIT 5 Frameworks. The main procedure involved relating OMREN's services and processes to the relevant chapter in TOGAF. Moreover, the IT governance was mainly built and applied according to the author's own IT experience, in relation to OMREN's identified structure and processes.

4.2 Limitations of the Research Methodology

The research methodology covered almost all OMREN's projects and processes. However, there were some limitations to the author's access to detailed processes, projects and operations carried out between interconnected departments in the organisation. A better clarification of the working environment and original OMREN roadmap would therefore have resulted in a more accurate EA framework, with a more precise design for all its work packages and projects. Furthermore, the organisation's daily practices could have been outlined in more detail in the EA and governance models developed.

4.3 Effectiveness of the Enterprise Architecture (EA)

The effectiveness of the developed EA and alignment of IT with OMREN's business objectives is the key target of this project. The EA developed covered four main ADM Phases (Phases E to H), with an intense focus on the organisation's management. All aspects of EA were successfully addressed, based on OMREN's vision and objectives, with the TOGAF Phases and steps being followed very carefully and thoroughly. The four ADM Phases (E to H) conformed to and continued the earlier work performed for Phases A to D. IT resources then helped to verify the roadmap and implementation plans created for the organisation. Moreover, the implementation of a consolidated plan for the services introduced by OMREN and a priority analysis helped create a migration plan for the project. The four phases were concluded with a methodology to monitor the change process, thus ensuring that the architecture would respond to needs and confirming that the value of the architecture to the business and services introduced by OMREN would be maximised.

4.3.1 Evaluation of TOGAF as a Framework for OMREN:

In the present author's opinion, TOGAF was the most suitable choice as a framework reference for building OMREN's EA, when compared to other frameworks. One positive feature noted in TOGAF was its neutrality and suitability for any kind of organisation. Applying TOGAF to OMREN was therefore a smooth process, which provided easy access to a wide variety of information and resources. Moreover, TOGAF is well structured and well organised, which meant that adaptation to OMREN's structure was fluent and easy to implement. ADM, representing the core of TOGAF, is divided into chapters and provides clear steps for implementation. This facilitated the phases of EA creation and production of artefacts and deliverables.

Conversely, there were some difficulties involved in using TOGAF. First, the framework document exceeds 500 pages in length. Moreover, the ADM Phases are very comprehensive, which is double-edged sword, in that although the Phases covered every minute aspect of the organisation, they became cumbersome to apply across all the steps. During the EA implementation, it was therefore necessary to omit some of the steps from the Framework, because they were not applicable to OMREN.

Nevertheless, TOGAF is still the closest to an ideal choice for overall EA development in OMREN in future, because it is a thorough framework; it covers all the organisation's needs

when building a complete EA in a well-structured, flexible and sustainable way. Another important feature of TOGAF is the availability of modelling tools, such as ArchiMate for designing and visualising the developed EA.

4.4 The Usefulness of Enterprise Architecture (EA) Governance and IT Governance

EA governance has provided good coverage of governance issues within OMREN. This is a holistic method of addressing an entire EA. It will serve as a guidance tool for managing and controlling all processes across OMREN. A useful feature of governance is that it works hierarchically across an organisation's domains, namely the corporate, technology, IT and architecture domains. The main characteristics of governance were identified in this project to organise the interconnected processes between all parties in the organisation.

More extensive work was conducted by modeling IT governance using the COBIT 5 Framework. This will help OMREN leverage its key resources and services. Applying the proposed governance framework and techniques, together with an appropriate strategy from the top management, will help improve the quality of the enterprise's services and clarify who owns the resources. Moreover, IT governance maximises the level of responsibility and performance amongst senior management and staff.

4.5 Personal Reflection and Evaluation

This project was an ideal opportunity to learn about EA and broaden knowledge in this field. Studying the TOGAF Framework and applying ADM was also good practice for enhancing analytical strengths and capabilities for developing EA throughout the detailed steps recommended in TOGAF.

However, a major difficulty in this current project was the time limit. Developing such EA within the time constraints of producing this dissertation was a big challenge. This was mainly due to the scale of the TOGAF Framework and the diversity of OMREN's projects. However, it represented a learning opportunity for better time management and organisation of workload, in that the project had to be broken down into smaller tasks or steps, so that the required goals could be achieved. Moreover, from this process of time management and skills learnt from ADM, a greater ability to prioritise tasks was developed through this project, which as the researcher, I will find useful in my future career. Furthermore, developing IT governance for OMREN using COBIT 5 contributed to my existing knowledge in the field of

IT management, which is closely related to my chosen career; improving the way in which I deal with daily tasks and processes in the IT department. Therefore, applying the five main principles of COBIT 5 was good practice for future situations involving the achievement of organisational objectives in IT investment. Moreover, I gained confidence in addressing stakeholder needs by building the ‘goals cascade’, which is a cohesive method of cascading enterprise goals on top of IT-related goals and finding suitable enablers for each project. My overall experience of using COBIT 5 was a good opportunity to extend my knowledge of building a full IT governance framework – knowledge which is likely to be useful in my future professional life.

4.6 OMREN’s Evaluation of the Developed EA and IT Governance

The developed EA was checked by OMREN’s senior management and they agreed that it covered most of the required ADM Phases. They were also happy with the suitability of TOGAF as a framework for building EA in public sector organisations. Based on the evaluation forms completed by the director and senior management of OMREN, there was a consensus that the EA developed would assist with OMREN’s strategic planning and the alignment of IT investment with the organisation’s goals. Moreover, the evaluation forms in Appendix B cover the IT governance developed on the basis of COBIT 5’s main principles, whereby it was agreed by the respondents that it would help OMREN’s management govern IT projects and processes in future.

4.7 Recommendations for Future Work

Future recommendations based on this dissertation project may be summarised in two main points concerning modelling and maintenance, which are further discussed in the following two sections.

4.7.1 Modelling:

With most of the EA framework being complete, another step is presented, which involves the organisation starting to acquire real-life architecture. An experienced team from OMREN with personnel who are fully aware of the organisation’s structure, projects, work packages and processes must therefore start modelling the EA, using an available modelling tool. One of the best options in this regard is ArchiMate, which is a modelling technique or language

used to describe EA. OMREN's architects can utilise a clear set of concepts, such as a UML and other visualisation principles to meet all the visualisation requirements. This will lead to the creation of a simple and uniform structure to describe all the content and domains of the enterprise.

4.7.2 Analysis and Maintenance:

Another important aspect of EA is maintenance. The EA as a whole can face certain difficulties in implementation at all organisational levels and domains. However, this may be rectified by designing and implementing maintenance procedures to enable the architecture to be modified and extended, based on feedback from stakeholders and practitioners. Nevertheless, this will rely on the original processes designed, whereby the perfect model must be identified for practices and operations performed at different time intervals.

Harmon (2003) suggests that a maintenance team should design a systematic process for generating and storing documentation, models and diagrams in an orderly way. Another approach proposed is to evaluate the EA periodically to confirm its alignment with business processes (Gomes, 2013).

4.7.3 Completing the IT Governance:

IT is important for the future implementation of IT governance in OMREN, using COBIT 5. A goals cascade approach should subsequently be adopted for all OMREN's projects and services, in order to gain a better understanding of real-life practices. There are also two other important chapters in the Framework, namely Implementation Guidance and the Process Capability Model. These need to be applied by OMREN to achieve a comprehensive IT governance framework.

Chapter 5 – Conclusion

Over the years, business and IT alignment have remained a high priority for organisations and decision-makers. However, despite all the methodologies and policies formulated, there has been a need for frameworks that will enable the best approaches to be organised and illuminated, so as to create strategic and detailed compliance between IT and business alignment. The aim of this dissertation project was to develop a full EA for the OMREN project. The EA was professionally implemented using a carefully designed procedure, involving numerous steps. It started by gaining an understanding and analysing all projects and services conducted by OMREN. This was followed by studying the TOGAF Framework, which is a large framework, outlined in detail in an extensive document. However, special attention was given to the ADM chapter. ADM implementation is considered to be the core of any EA framework development, as achieved in this project. Although the TOGAF Framework was too extensive to be covered in full during the timeframe for writing this project, it was essential for building the EA and gaining knowledge for the author's future career. This is because the Framework clarifies the concepts of building EA, and aligning IT processes and projects with an organisation's business objectives and strategies, in a scientific and professional manner.

The other part of the project addressed overall EA governance, with a focus on IT governance. This was also an important step towards understanding the basics of IT management. The five main principles of the COBIT 5 Framework were covered in full and implemented in OMREN. Moreover, many techniques of managing and following up IT projects were included, and a proposal was prepared for future use by the organisation.

References

- Al-Habsi, W. (2016) Developing an Enterprise Architecture for the OMREN Project Based on TOGAF: Part of the Strategic Planning and Feasibility Study [MSc Dissertation]. Cardiff University.
- Assist Knowledge Development. (2014) [Online videos]. Available at: <https://www.assistkd.com/knowledge-hub/videos> [Accessed 7 July 2018].
- Bernard, S. (2012) An Introduction to Enterprise Architecture (3rd ed.). Bloomington, Ind.: AuthorHouse.
- Brooks, T. (2009) ‘Enterprise Architecture Governance: A Framework Approach’, Architecture & Governance Magazine, 5, pp.5-7.
- Cms.gov. (2008) [Website]. Available at: <https://www.cms.gov/Research-Statistics-Data-and-Systems/CMS-Information-Technology/XLC/Downloads>SelectingDevelopmentApproach.pdf> [Accessed 13 Aug. 2018].
- COBIT 5 (2012) A Business Framework for the Governance and Management of Enterprise IT. IL: ISACA.
- Coetzee, F. (2018) ‘A Brief History of Enterprise Architecture’ [online], Xpdianea Blogspot. Available at: <http://xpdianea.blogspot.com/2009/08/brief-history-of-enterprise.html> [Accessed 3 July 2018].
- Dang, D. (2018) Enterprise Architecture in the Public Sector - Adoption and Institutionalization [Ph.D. Thesis]. Tampere University of Technology.
- Desai, F. (2016) ‘The Digital Era is Crippling the Five Year Strategic Plan’ [online]. Forbes. Available at: <https://www.forbes.com/sites/falgunidesai/2016/04/28/the-digital-era-is-crippling-the-five-year-strategic-plan/> [Accessed 10 Sept. 2018].
- Eitbokwiki.org. (2017) Enterprise Information Technology Body of Knowledge – EITBOK [online]. Available at: http://eitbokwiki.org/Enterprise_Architecture [Accessed 22 July 2018].
- European Commission (2018) ‘Strengthening project internal monitoring’ [online], Ec.europa.eu. Available at: https://ec.europa.eu/europeaid/sites/devco/files/methodology-tools-and-methods-series-strengthening-project-internal-monitoring-200706_en_2.pdf [Accessed 4 Sept. 2018].
- Geng, J., Niu, S. and Li, Z. (2014) ‘Using Enterprise Architecture to Direct IT Governance’, Advanced Materials Research, 971-973, pp.2452-2457.

- Gladden, M. (2017) Neuroprosthetic Supersystems Architecture (1st ed.). [S.l.]: Synthypnion Academic, pp.182-209.
- Gomes, R. (2013). Methodology for Building and Maintaining Enterprise Architectures in Small And Medium Enterprises [MSc. Dissertation]. University of the Algarve.
- Government of Western Australia. (2017) Enterprise Architecture in the Public Service. Office of the Government - Chief Information Officer.
- Harmon, P. (2003) 'Developing an Enterprise Architecture', Business Process Trends [online]. Available at: <https://www.bptrends.com/bpt/wp-content/publicationfiles/Enterprise%20Architecture%20Whitepaper-1-23-03.pdf> [Accessed 11 Sept. 2018].
- Heikkilä, J. and Penttinen, K. (2016) Overview of Enterprise Architecture Work in 15 Countries [online]. Available at: https://www.researchgate.net/publication/294663617_Overview_of_Enterprise_Architecture_work_in_15_countries [Accessed 13 July 2018].
- Hugoson, M., Pessi, K. and Magoulas, T. (2011) 'Enterprise Architecture Principles and Their Impact on the Management of IT Investments', The Electronic Journal Information Systems Evaluation [online], 14(1), pp.53-62. Available at: http://issuu.com/academic-conferences.org/docs/ejise-volume14-issue1-article700?mode=a_p [Accessed 9 July 2018].
- Josey, A. (2011) TOGAF® Version 9.1 A Pocket Guide. Zaltbommel: Van Haren Publishing.
- Khanyile, S. and Abdullah, H. (2013) COBIT 5: An Evolutionary Framework and Only Framework to Address the Governance and Management of Enterprise IT [online]. Available at: <http://osprey.unisa.ac.za/TechnicalReports/Cobit5.pdf> [Accessed 12 Sept. 2018].
- Kotusev, S. (2016) [Website]. Available at: <http://kotusev.com/The%20History%20of%20Enterprise%20Architecture%20-%20An%20Evidence-Based%20Review.pdf> [Accessed 28 June 2018].
- Lankhorst, M. (2013) Enterprise Architecture at Work (3rd ed.). Berlin, Heidelberg: Springer Berlin Heidelberg.
- Lankhorst, M. (2017) Enterprise Architecture at Work (4th ed.). [S.l.]: Springer.
- Maguire, S. and Sparx, S. (2017) Enterprise Architecture - User Guide Series. [online]. Available at: <https://sparxsystems.com.au/resources/user-guides/guidebooks/enterprise-architecture.pdf> [Accessed 4 July 2018].

- Malik, N. (2018) ‘What is the best enterprise architecture framework?’ Quora. [online]. Available at: <https://www.quora.com/What-is-the-best-enterprise-architecture-framework> [Accessed 13 Aug. 2018].
- Mar, A. (2012) ‘The KISS of Enterprise Architecture Governance’ [online], Simplicable. Available at: <https://arch.simplifiable.com/arch/new/the-KISS-of-enterprise-architecture-governance> [Accessed 7 Sept. 2018].
- Mar, A. (2016) ‘8 Enterprise Architecture Risks’ [online], Simplicable. Available at: <https://arch.simplifiable.com/arch/new/8-enterprise-architecture-risks> [Accessed 6 Sept. 2018].
- Marchand, D. and Peppard, J. (2008). DESIGNED TO FAIL: WHY IT PROJECTS UNDERACHIEVE AND WHAT TO DO ABOUT IT. [online]. Available at: https://nanopdf.com/download/Designed-to-fail-why-it-projects-underachieve-and-what-to-do_pdf# [Accessed 1 Aug. 2018].
- Marciano, J. (2015) Applying COBIT in a Government Organization [online]. Available at: <http://www.isaca.org/COBIT/focus/Pages/applying-cobit-in-a-government-organization.aspx> [Accessed 9 Sept. 2018].
- Niemi, E. and Ylimäki, T. (2007) ‘Defining Enterprise Architecture Risks in a Business Environment’ [online], Jyväskylä: The European Biosecurity Regulators Forum. Available at: https://jyx.jyu.fi/bitstream/handle/123456789/41378/Article_EA_Risks.pdf?sequence=1&isAllowed=y [Accessed 6 Sept. 2018].
- Opengroup.org. (2018) TOGAF - Frequently Asked Questions [online]. Available at: http://www.opengroup.org/public/arch/p1/togaf_faq.htm [Accessed 3 July 2018].
- Orbussoftware.com. (2018) ADM Phase H: Architecture Change Management. [online]. Available at: <https://www.orbussoftware.com/resources/videos/the-adm-phases/adm-phase-h-architecture-change-management/#> [Accessed 1 Sept. 2018].
- Parmo, C. (2009) The Use of Enterprise Architecture, IT Strategy and IT Governance at StatoilHydro [online]. Available at: <https://daim.idi.ntnu.no/masteroppgaver/004/4545/masteroppgave.pdf> [Accessed 7 Sept. 2018].
- Racichart.org. (2018) RACI Chart, Instructions, and Excel Download — RACI Charts – How-to Guide and Templates [online]. Available at: <http://racichart.org/> [Accessed 12 Sept. 2018].
- Ranami, N. (2002). Corporate Governance – An Essential Guide for South African Companies. LexisNexis South Africa.

Ross, J. and Weill, P. (2004) IT Governance. Boston, USA: Harvard Business School Press, pp.155-182.

Pmoguru.com (2016) ‘Project Prioritisation: How to Prioritise Projects’, PMO Guru [online]. Available at: <http://www.pmoguru.com/project-prioritisation-prioritise-projects/> [Accessed 11 Aug. 2018].

Simplilearn.com. (2018) COBIT® 5 Principles 4 and 5 Tutorial [online]. Available at: <https://www.simplilearn.com/cobit-5-principles-4-and-5-tutorial-video> [Accessed 11 Sept. 2018].

Soenen, P. (2012) http://www.qualified-audit-partners.be/user_files/QECB_IIA_COBIT5_EN_Overview_201111.pdf. [online]. Available at: http://www.qualified-audit-partners.be/user_files/QECB_IIA_COBIT5_EN_Overview_201111.pdf [Accessed 11 Sept. 2018].

Stoy, A. (2018) ‘IT Project Risk Examples - Common Risks in IT Projects & How to Avoid Them’ [online], Brighthub Project Management. Available at: <https://www.brighthubpm.com/risk-management/90414-it-project-risk-examples/> [Accessed 5 Sept. 2018].

Tabia, K., Benferhat, S. and Ali, M. (2017) Advances in Artificial Intelligence (1st ed.). Arras: Springer, pp.9-18.

Tamm, T., Seddon, P., Shanks, G. and Reynolds, P. (2011) ‘How Does Enterprise Architecture Add Value to Organisations?’ Association for Information Systems, 28(1).

The Open Group Architecture Forum. (2018) The TOGAF Standard, Version 9.2. The Open Group.

van der Torre, L. and van Zee, M. (2017) ‘Rational Enterprise Architecture’, Advances in Artificial Intelligence: From Theory to Practice, pp.9-18.

Vries, M. and Rensburg, A. (2008) ‘Enterprise Architecture – New Business Value Perspectives’ [online]. Sajie Journals. Available at: <http://sajie.journals.ac.za/pub/article/view/103/99> [Accessed 4 July 2018].

Weisman, R. (2011) An Overview of TOGAF® Version 9.1 [online]. Available at: http://www.opengroup.org/public/member/proceedings/q312/togaf_intro_weisman.pdf [Accessed 16 July 2018].

Yesser (2018) The National Enterprise Architecture Framework [online]. Available at: https://www.yesser.gov.sa/EN/BuildingBlocks/NATIONAL_EA/Pages/General_Framework_and_Tar... [Accessed 4 July 2018].

Zororo,, T. (2015). Driving Enterprise IT Strategy Alignment and Creating Value Using the COBIT 5 Goals Cascade. ISACA COBIT Focus. [online] Available

at: <http://www.isaca.org/COBIT/focus/Pages/driving-enterprise-it-strategy-alignment-and-creating-value-using-the-cobit-5-goals-cascade.aspx> [Accessed 9 Sep. 2018].

Appendix A: COBIT 5

CHAPTER 2

PRINCIPLE 1: MEETING STAKEHOLDER NEEDS

Figure 5—COBIT 5 Enterprise Goals					
BSC Dimension	Enterprise Goal	Relation to Governance Objectives			
		Benefits Realisation	Risk Optimisation	Resource Optimisation	
Financial	1. Stakeholder value of business investments	P		S	
	2. Portfolio of competitive products and services	P	P	S	
	3. Managed business risk (safeguarding of assets)		P	S	
	4. Compliance with external laws and regulations		P		
	5. Financial transparency	P	S	S	
Customer	6. Customer-oriented service culture	P		S	
	7. Business service continuity and availability		P		
	8. Agile responses to a changing business environment	P		S	
	9. Information-based strategic decision making	P	P	P	
	10. Optimisation of service delivery costs	P		P	
Internal	11. Optimisation of business process functionality	P		P	
	12. Optimisation of business process costs	P		P	
	13. Managed business change programmes	P	P	S	
	14. Operational and staff productivity	P		P	
	15. Compliance with internal policies		P		
Learning and Growth	16. Skilled and motivated people	S	P	P	
	17. Product and business innovation culture	P			

Figure 6—IT-related Goals		
IT BSC Dimension	Information and Related Technology Goal	
Financial	01	Alignment of IT and business strategy
	02	IT compliance and support for business compliance with external laws and regulations
	03	Commitment of executive management for making IT-related decisions
	04	Managed IT-related business risk
	05	Realised benefits from IT-enabled investments and services portfolio
	06	Transparency of IT costs, benefits and risk
Customer	07	Delivery of IT services in line with business requirements
	08	Adequate use of applications, information and technology solutions
Internal	09	IT agility
	10	Security of information, processing infrastructure and applications
	11	Optimisation of IT assets, resources and capabilities
	12	Enablement and support of business processes by integrating applications and technology into business processes
	13	Delivery of programmes delivering benefits, on time, on budget, and meeting requirements and quality standards
	14	Availability of reliable and useful information for decision making
	15	IT compliance with internal policies
Learning and Growth	16	Competent and motivated business and IT personnel
	17	Knowledge, expertise and initiatives for business innovation

Figure 7—Governance and Management Questions on IT

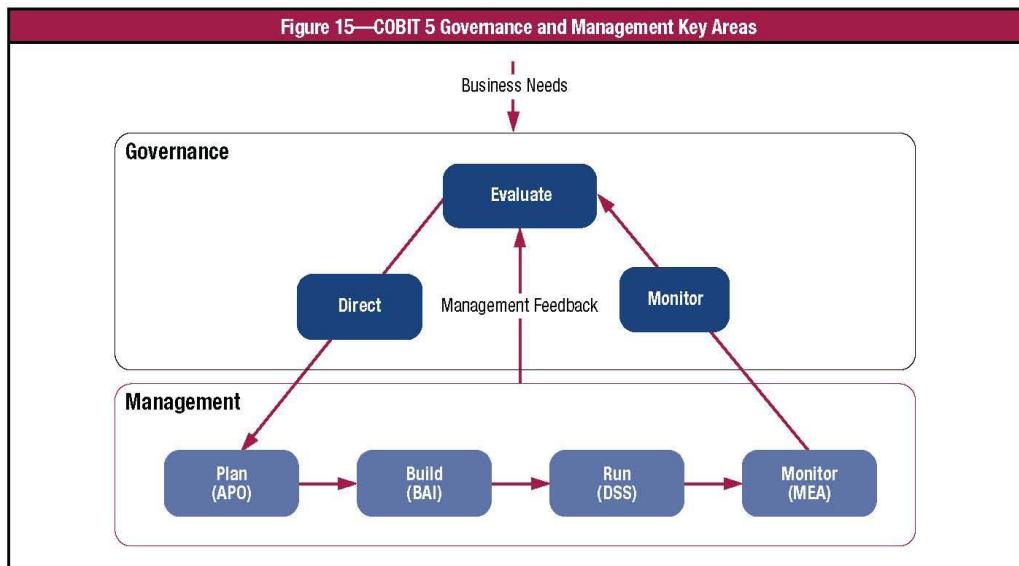
Internal Stakeholders	Internal Stakeholder Questions
<ul style="list-style-type: none"> • Board • Chief executive officer (CEO) • Chief financial officer (CFO) • Chief information officer (CIO) • Chief risk officer (CRO) • Business executives • Business process owners • Business managers • Risk managers • Security managers • Service managers • Human resource (HR) managers • Internal audit • Privacy officers • IT users • IT managers • Etc. 	<ul style="list-style-type: none"> • How do I get value from the use of IT? Are end users satisfied with the quality of the IT service? • How do I manage performance of IT? • How can I best exploit new technology for new strategic opportunities? • How do I best build and structure my IT department? • How dependent am I on external providers? How well are IT outsourcing agreements being managed? How do I obtain assurance over external providers? • What are the (control) requirements for information? • Did I address all IT-related risk? • Am I running an efficient and resilient IT operation? • How do I control the cost of IT? How do I use IT resources in the most effective and efficient manner? What are the most effective and efficient sourcing options? • Do I have enough people for IT? How do I develop and maintain their skills, and how do I manage their performance? • How do I get assurance over IT? • Is the information I am processing well secured? • How do I improve business agility through a more flexible IT environment? • Do IT projects fail to deliver what they promised—and if so, why? Is IT standing in the way of executing the business strategy? • How critical is IT to sustaining the enterprise? What do I do if IT is not available? • What critical business processes are dependent on IT, and what are the requirements of business processes? • What has been the average overrun of the IT operational budgets? How often and how much do IT projects go over budget? • How much of the IT effort goes to fighting fires rather than to enabling business improvements? • Are sufficient IT resources and infrastructure available to meet required enterprise strategic objectives? • How long does it take to make major IT decisions? • Are the total IT effort and investments transparent? • Does IT support the enterprise in complying with regulations and service levels? How do I know whether I am compliant with all applicable regulations?
External Stakeholders	External Stakeholder Questions
<ul style="list-style-type: none"> • Business partners • Suppliers • Shareholders • Regulators/government • External users • Customers • Standardisation organisations • External auditors • Consultants • Etc. 	<ul style="list-style-type: none"> • How do I know my business partner's operations are secure and reliable? • How do I know the enterprise is compliant with applicable rules and regulations? • How do I know the enterprise is maintaining an effective system of internal control? • Do business partners have the information chain between them under control?

How to Find an Answer to These Questions

All questions mentioned in figure 7 can be related to the enterprise goals, and serve as input to the goals cascade, upon which they can be addressed effectively. Appendix D contains an example mapping between the internal stakeholder questions mentioned in figure 7 and enterprise goals.

COBIT 5 Process Reference Model

COBIT 5 is not prescriptive, but it advocates that enterprises implement governance and management processes such that the key areas are covered, as shown in figure 15.



An enterprise can organise its processes as it sees fit, as long as all necessary governance and management objectives are covered. Smaller enterprises may have fewer processes; larger and more complex enterprises may have many processes, all to cover the same objectives.

COBIT 5 includes a process reference model, which defines and describes in detail a number of governance and management processes. It represents all of the processes normally found in an enterprise relating to IT activities, providing a common reference model understandable to operational IT and business managers. The proposed process model is a complete, comprehensive model, but it is not the only possible process model. Each enterprise must define its own process set, taking into account its specific situation.

Incorporating an operational model and a common language for all parts of the enterprise involved in IT activities is one of the most important and critical steps towards good governance. It also provides a framework for measuring and monitoring IT performance, providing IT assurance, communicating with service providers, and integrating best management practices.

The COBIT 5 process reference model divides the governance and management processes of enterprise IT into two main process domains:

- **Governance**—Contains five governance processes; within each process, evaluate, direct and monitor (EDM)⁵ practices are defined.
- **Management**—Contains four domains, in line with the responsibility areas of plan, build, run and monitor (PBRM), and provides end-to-end coverage of IT. These domains are an evolution of the COBIT 4.1 domain and process structure. The names of the domains are chosen in line with these main area designations, but contain more verbs to describe them:
 - Align, Plan and Organise (APO)
 - Build, Acquire and Implement (BAI)
 - Deliver, Service and Support (DSS)
 - Monitor, Evaluate and Assess (MEA)

⁵ In the context of the governance domain, ‘monitoring’ means those activities where the governance body checks to what extent the direction that has been set for management is actually applied.

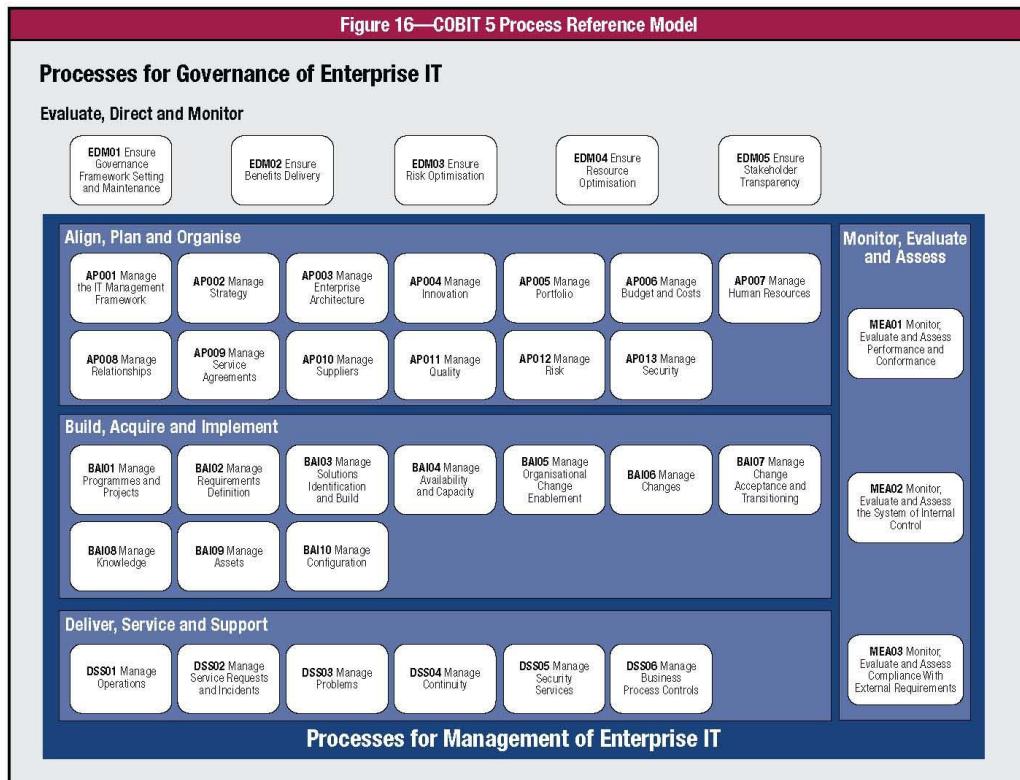
CHAPTER 6

PRINCIPLE 5: SEPARATING GOVERNANCE FROM MANAGEMENT

Each domain contains a number of processes. Although, as described previously, most of the processes require ‘planning’, ‘implementation’, ‘execution’ and ‘monitoring’ activities within the process or within the specific issue being addressed (e.g., quality, security), they are placed in domains in line with what is generally the most relevant area of activity when looking at IT at the enterprise level.

The COBIT 5 process reference model is the successor of the COBIT 4.1 process model, with the Risk IT and Val IT process models integrated as well.

Figure 16 shows the complete set of 37 governance and management processes within COBIT 5. The details of all processes, according to the process model described previously, are included in *COBIT 5: Enabling Processes*.



Appendix B: Evaluation Forms for the Developed EA



Cardiff University
School of Computer Science and Informatics

Managing OMREN Project Based on TOGAF and COBIT 5 Frameworks

Evaluation Form

Note: This form was created to evaluate the developed Enterprise Architecture (EA) for the OMREN. The EA was developed as part of a Master's dissertation project supervised by Dr Wendy Ivins from School of Computer Science and Informatics – Cardiff University.

Said Al-Maskari – Student ID: 1346289
Cardiff University
September 2018

Name: Warda Al-Habsi

Organisation: The Research Council- OMREN Project

Job Title: OMREN Project Manager Applications

Q1: Is developing an Enterprise Architecture important for OMREN?

Definitely the developed EA is important for OMREN project. This EA and the previous developed EA in 2016 will form a complete roadmap that should be used in managing and aligning the resources and services effectively to achieve the OMREN objectives.

Although there are major improvements in OMREN project since 2016, but the developed EA will be the building block of the future comprehensive EA.

Q2: Do you think using TOGAF framework as a reference was a good choice for building OMREN's EA?

Yes, TOGAF framework is one of the best frameworks used in developing EA for public projects or entities. OMREN is a project managed by a public entity; therefore, this framework can be applied to develop an Enterprise Architecture for OMREN.

Q3: Is the developed enterprise architecture important for aligning and compliance of IT with the business processes in OMREN?

Yes, the applied phases of TOGAF and the COBIT 5 rules and techniques will be useful to achieve the effective alignment between OMREN business processes and the provided IT services.

Name: Warda Al-Habsi

Organisation: The Research Council- OMREN Project

Job Title: OMREN Project Manager Applications

Q1: Is developing an Enterprise Architecture important for OMREN?

Definitely the developed EA is important for OMREN project. This EA and the previous developed EA in 2016 will form a complete roadmap that should be used in managing and aligning the resources and services effectively to achieve the OMREN objectives.

Although there are major improvements in OMREN project since 2016, but the developed EA will be the building block of the future comprehensive EA.

Q2: Do you think using TOGAF framework as a reference was a good choice for building OMREN's EA?

Yes, TOGAF framework is one of the best frameworks used in developing EA for public projects or entities. OMREN is a project managed by a public entity; therefore, this framework can be applied to develop an Enterprise Architecture for OMREN.

Q3: Is the developed enterprise architecture important for aligning and compliance of IT with the business processes in OMREN?

Yes, the applied phases of TOGAF and the COBIT 5 rules and techniques will be useful to achieve the effective alignment between OMREN business processes and the provided IT services.

Q4: Is the IT Governance important for OMREN?

Yes, it is important for OMREN as it help improving and maintaining high-quality information to support business decisions. Moreover, it will ensure IT risk is managed effectively.

Q5: Will the principles, techniques and recommendation developed in the “IT Governance” section be useful for the management of OMREN’s IT projects and processes?

Certainly, the applied principles and techniques in each domain are useful and will help OMREN management

Date: 19 September 2018

Signature: 

Please TYPE or write in BLACK ink and use BLOCK capitals

**SECTION A: TO BE COMPLETED BY THE CANDIDATE AND SUBMITTED
WITH THE DISSERTATION**

Student ID Number:	C1346289	
Title:	Please circle appropriate value <input checked="" type="radio"/> Mr / <input type="radio"/> Miss/ Ms/ Mrs/ Dr/ Rev/ Other, please specify	
Surname:	AL-MASKARI	
First Names:	SAID AHMED NASSER	
School:	SCHOOL OF COMPUTER SCIENCE & INFORMATICS	
Title of Degree:	Please circle appropriate value <input checked="" type="radio"/> MA / <input checked="" type="radio"/> MScEcon/ <input type="radio"/> MBA / <input type="radio"/> MEd / <input type="radio"/> LLM / <input type="radio"/> MMus/ <input type="radio"/> MTh / <input type="radio"/> MPH / <input type="radio"/> MScD / Other, please specify	
Full Title of Dissertation submitted:	Enterprise Architecture: Managing an Oman Research and Education Network (OMREN) Project Based on the TOGAF and COBIT 5 Frameworks	
Is this a resubmission?	Yes	<input type="checkbox"/>
	No	<input checked="" type="checkbox"/>
Dissertation submitted for Examination in:	Permanent Binding <input type="checkbox"/> Temporary binding <input type="checkbox"/>	

Supervisor's Name:	DR. WENDY IVINS
Address for receipt of your Result Letter, Degree Certificate and Details of the Graduation Ceremony:	5 Acorn Grove CF23 8SH Pontprennau Cardiff
Please indicate whether you wish to attend the Degree Ceremony:	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
Preferred Contact Telephone (with dialling code/s):	
Email/s:	Saeed.almaskari@gmail.com 0096899440699

CANDIDATE'S SIGNATURE: ..  ..

DATE OF SUBMISSION: 21 / 09 / 2018

SECTION B: TO BE COMPLETED BY THE SCHOOL

Please tick the appropriate box to confirm that the following documents have been completed by the candidate and deposited in the School.

Dissertation Summary Sheet:	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Statements and Declaration:	Yes <input type="checkbox"/>	No <input type="checkbox"/>
A signed statement regarding availability of the Dissertation:	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Where Candidate is resubmitting, School should attach cheque (or evidence that the fee has been paid):	Yes <input type="checkbox"/>	No <input type="checkbox"/>

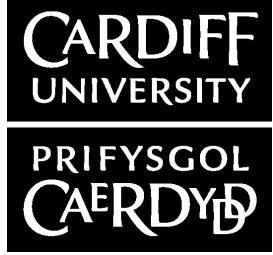
SCHOOL'S SIGNATURE:

DATE: / /

POSITION:

HYSBYSIAD O GYFLWYNO: GRADDAU ÔL-RADDEDIG A ADDYSGIR

TEIPIWCH neu ysgrifennwch mewn inc DU a defnyddiwch BRIFLYTHRENNAU

**ADRAN A: I'W LLENWI GAN YR YMGEISYDD A'I CHYFLWYNO GYDA'R TRAETHAWD HIR**

Rhif Adnabod y Myfyriwr:	
Teitl:	Rhowch gylch o gwmpas y teitl priodol Mr/ Miss/ Ms/ Mrs/ Dr/ Y Parch/ Arall, rhowch ef
Cyfenw:	
Enwau Cyntaf:	
Ysgol:	
Teitl y Radd:	Rhowch gylch o gwmpas y teitl priodol MA / MSc/ MScEcon/ MBA / MEd / LLM / MMus/ MTh / MPH / MScD / Arall, rhowch ef
Teitl Llawn y Traethawd Hir a gyflwynir:	
Ai ailgyflwyniad yw hwn?	Ie <input type="checkbox"/> Na <input type="checkbox"/>
Cyflwynir y Traethawd Hir i'w Arholi mewn:	Rhwymiad Parhaol <input type="checkbox"/> Rhwymiad dros dro <input type="checkbox"/>
Enw'r Goruchwyliwr:	

Y Cyfeiriad ar gyfer cael eich Llythyr Canlyniad, eich Tystysgrif Gradd a Manylion eich Seremoni Raddio:	
Cod Post (os yw'n gymwys):	
A ydych chi'n dymuno dod i'r Seremoni Raddio:	Ydwyt <input type="checkbox"/> Nac ydwyt <input type="checkbox"/>
Rhif Ffôn i Gysylltu â chi (gyda'r cod(au) deialu):	
Cyfeiriad(au) e-bost:	

LLOFNOD YR YMGEISYDD: **DYDDIAD CYFLWYNO:** / /

ADRAN B: I'W LLENWI GAN YR YSGOL

Ticiwch y blwch priodol i gadarnhau bod y dogfennau isod wedi'u llenwi gan yr ymgeisydd ac wedi'u rhoi ar adnau yn yr Ysgol.

Taflen y Crynodeb o'r Traethawd Hir:	Ydyw <input type="checkbox"/> Nac ydyw <input type="checkbox"/>
Y Gosodiadau a'r Datganiad:	Ydynt <input type="checkbox"/> Nac ydynt <input type="checkbox"/>
Gosodiad, sydd wedi'i lofnodi, ynghylch argaeledd y Traethawd Hir:	Ydyw <input type="checkbox"/> Nac ydyw <input type="checkbox"/>
Os yw'r Ymgeisydd yn ailgyflwyno, dylai'r Ysgol gysylltu'r siec (neu dystiolaeth bod y ffi wedi'i thalu) wrth y ffurflen hon:	Ydyw <input type="checkbox"/> Nac ydyw <input type="checkbox"/>

LLOFNOD YR YSGOL: **DYDDIAD:** / /

SWYDD: