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Extending the Capacity of Enterprise Architecture Management Frameworks Towards a model-driven handling of dynamics

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**Extending the Capacity of Enterprise Architecture Management
Frameworks:
Towards a model-driven handling of dynamics**

by

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supervised by

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A thesis submitted in partial fulfilment of the
degree of Doctor of Philosophy

in the Department of Informatics

in the Faculty of Natural & Mathematical Sciences

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



ABSTRACT

Most large modern enterprises comprise different departments, subsidiaries, and divisions internally, and each of these will typically operate multiple, interdependent, information technology systems. Externally, all enterprises face dynamic and sometimes turbulent environments, with ongoing changes in laws and regulations, technologies, competition, customer preferences, and marketplace changes. These ongoing external dynamics will impact on the enterprise's goals and strategies, and thus on their IT systems and processes.

Enterprise architecture management (EAM) frameworks have proven to be a valuable and widespread means of representing the internal IT systems of enterprises, and of representing links of these systems to the organization's goals and strategies. But how well do EAM frameworks cope with the dynamic environments that organizations face? It turns out not well. Indeed, common EAM frameworks are mostly static. In practice, enterprises opt to build their own adapted approach on top of standard frameworks. Stakeholders use their capacity and attempt to incorporate implicit knowledge and business behaviour specific to their own enterprise.

Based on an action research case study undertaken in a large, complex business enterprise in Saudi Arabia, we propose a methodology for managing changing business behaviour. This builds on selecting existing and well-established approaches in line with EAM frameworks. This is achieved by an extended meta-model offering further capacity with new constituents enabling the representation of time-knowledge for changing sources of information, and new constituents enabling constant maintenance of enterprise architecture (EA) models. In addition, the incorporation of the changing business behaviour is facilitated via guidelines for the modelling of different stakeholders' collective-thinking/mental-modelling in order to offer a shared understanding of business behaviour. Furthermore, we propose a number of techniques relying on the extended meta-model to facilitate the constant maintenance of the EA landscape. These techniques use the capacity of the extended meta-model to represent multiple states of the EA reflecting changing elements to compliment the architectural development method (ADM) of the open group architecture framework (TOGAF). Our methodology is driven by action research to ensure the applicability and real-world relevance of our solution, which is itself a novel approach in the EAM field.

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Faisal A. Almisned

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Chapter 1

Introduction

This chapter introduces the scope and elements concerned in the research. The first Section (1.1) of this chapter introduces the terms that are central to the scope of our research. The second Section (1.2) describes the motivation driving the research. The third Section (1.3) introduces the research problem and questions. The fourth Section (1.4) identifies the novel contribution of this research.

1.1 Introduction

The abstract explanation of the research area and problem is offered in Chapter (2). This section describes the terms that are central to the scope of our research:

Business Behaviour:

Schekkerman defines business behaviour as ‘an ordering of tasks and/or activities that accomplish business goals and satisfy business commitments. It includes manual operations and is triggered by events in the environment or by internal initiatives or conditions. It is justified because it either generates value for the business or mitigates costs to the business. It is governed by commitments. Business behaviour is what produces the outcomes that fulfil the purpose of the business’ (Schekkerman (2006)). It can invoke different functions and uses diverse resources in the business so as to reach the required outcome. We propose new constituents to offer further capacity enabling the representation of time-knowledge of the events triggering changes in business behaviour, see Section (6.3) in Chapter (6).

Business behaviour should not be confused with business process that is well covered in the enterprise architecture (EA) Landscape (Ross et al. (2006); Schekkerman (2006); Task-force, IFIP-IFAC (2003)). Stakeholders carry out the majority of the business behaviour activities rather than information systems. It includes the implicit knowledge in the minds of relevant stakeholders. Different mental models occur in the minds of stakeholders responsible for a shared EA model; the common practice to reach shared understanding is via interviews and discussion which is not always attainable for isolated and external structures.

Business behaviour dynamics refer to parts of the business behaviour that are constantly affected by ongoing changes internally and externally, which subsequently change business goals. It include the ways in which businesses adapt standard Enterprise Architecture Management (EAM)¹ frameworks to reach improved representation of their EA. We propose a methodology for organization in order to improve their EAM ability to represent business behaviour dynamics in their EA, see Chapter (6).

EA landscape management:

The EA landscape consists of a number of EA states, with consideration of alternative representations. **Baseline/current EA state** depicts the current architecture state of the enterprise using several means. It is also called **As-Is** EA state. The state encloses the technological infrastructure and the existing business activities. **Target/future EA state** depicts the upcoming architecture state of the enterprise. It is also called **To-Be** EA state. The state is derived from enterprise objectives and plans for business and technology. It shows the effects on the enterprise infrastructure and business practices.

The progression of states is driven by a **Transformation plan** that describes the utilized practice to transform the current EA state to the target EA state. Our solution proposes new constituents to offer further capacity extending the practices of EA landscape management, see Section (6.3) in Chapter (6). An example is different scheduled activities, which can be simultaneous or interreliant. In addition, it illustrates gradual stages of progress. It is also called a sequencing plan. The transformation plan takes a document form. Further detailed descriptions can be found in Chapter (2).

Initiatives:

An initiative is a means of changing the architecture of an enterprise; assigned stakeholders are responsible for transforming the EA. A few EAM frameworks refer to the term ‘project’ with the same context as initiative. A new initiatives has to update the information represented in the EA (Chen et al. (2013)). Examples of initiatives are new business goals,

¹A list of abbreviations used more than once is provided in Appendix (C).

new sources of information, changes in information systems or new business project. We identify the group of initiatives triggering the update of EA models, see Chapter (6).

Stakeholders:

A stakeholder describes any member of an organization that has a particular concern fulfilled by EAM, it also describes all participants in any processes of the used EAM framework. A number of stakeholders from various structures, i.e. new initiatives, strategies, business, or IT, participate to produce an information model of EA. The communication and agreement between involved stakeholders is crucial to the success of EAM ([Ahlemann et al. \(2012\)](#); [Avgeriou et al. \(2007\)](#)); we propose a set of guidelines to reach shared understanding, see Section (6.4) in Chapter (6).

Maintenance of EA models:

It is the process of maintaining accurate and up-to-date data in the represented EA models that is necessary to reach correct decisions about target EA states. It involves gathering various information objects, and assigning stakeholders roles in line with their department to maintain their data. It involves deciding to add, delete, or update specific information objects while ensuring different responsible stakeholders agree with the decision. The traceability of stakeholders' decisions is part of the data maintenance of EA models. It can be referred to as data gathering/acquisition process in some frameworks. It is usual for stakeholders to gather information by discussion with other relevant stakeholders and then adding information to the relevant model. A number of publications have highlighted that maintaining EA models is a main challenge of EAM facing organizations in reality ([Fischer et al. \(2007\)](#); [Laube et al. \(2012\)](#); [Schekkerman \(2006\)](#)). We propose a number of techniques to deal with constantly maintaining the EA models in line with ongoing change that exploit the capacity of our extended model, see Section (6.5) in Chapter (6).

Technical Action Research (TAR):

TAR is a form of action research; it is an artefact-driven rather than a problem-driven approach ([Kock \(2007\)](#)). TAR is the attempt to use a solution² in the real world by interacting it with a particular problem context, with the goal of improving the context ([Baskerville \(1997\)](#)). We used the principles of TAR to drive our research methodology. Technical action research (TAR) consists of two engineering cycles. We describe the design of our research methodology in Chapter (3), with the explanation behind the choice of TAR over other forms of action research.

²We use the term solution to refer to our proposed methodology with the extended meta-model.

Our action case study was part of our research methodology and was undertaken in Riyadh, Saudi Arabia. This action case study was conducted at a large semi-governmental company called Al-Elm; it is owned by the Public Investment Fund (PIF), the investment arm of the Saudi Arabian Ministry of Finance ([Elm](#)). Al-Elm provides services to enterprises in both the private and public sector. The annual budget obtainable for these developments is in excess of one billion pounds. Al-Elm employs about 2000 employees spread over a number of cities in Saudi Arabia. See Appendix A for more details.

The action case study took place from March 2014 to November 2014. The feedback and remarks process was extended until June 2015. An official authorization from Al-Elm to carry out this action case study was granted; it was organized during the six months prior to the start of the action case study. The extensive literature examination, problem identification, and initial design of the solution was realized before the structured action case study.

King Saud University was the coordinator between Al-Elm and Faisal Almisned, who is a lecturer at King Saud University. The approval involved a one-year full collaboration with the Research and Development Unit (RDU) at Al-Elm. An internal assessment by the company was put in place. Al-Elm was thought to be a model environment for such an action case study. In addition, Al-Elm employs EAM throughout its hierarchy, and it uses a customization of the open group architecture framework (TOGAF) ([The Open Group \(2009b\)](#)). See Section (3.2.4) for more details of the action case study.

1.2 Motivation

We present existing approaches addressing parallel research concerns in Chapter (2), in addition to EAM frameworks' viewpoint on these concerns. In Chapter (3), we discuss how we chose to improve particular aspects of EAM in order to satisfy the raised concerns. Chapters (4) and (5) discuss the influence of the contextual factors surrounding our action case study on determining which aspects to address. This section summarizes the motivation driving our research:

The development of an EAM function adaptable to dynamic environments is a complex mission ([Ahlemann et al. \(2012\)](#); [Hauder et al. \(2012\)](#); [Maynard and Gilson \(2014\)](#); [Weiss et al. \(2013\)](#)). A few attempts have been made in the literature to address partial aspects of the same goal, specifically the approaches proposed by Ernst in ([Ernst \(2010\)](#)), Buckl in ([Buckl et al. \(2007\)](#)), and Fischer in ([Fischer et al. \(2007\)](#)). These approaches are analysed

in Chapter (2).

However, these previous approaches share one weakness: they complicate the implementation of the EAM function and raise its cost. This conflicts with EAMs principles (Ahlemann et al. (2012)). In addition, the applicability of such approaches is undermined by the complexity of building a customized EA modelling language, which is difficult to implement in reality. These two weaknesses highlight the need for a further proposal (Ahlemann et al. (2012); Hauder et al. (2012)).

Each of the existing approaches has considerable benefits. Nevertheless their drawbacks motivate our research:

- Their simplicity and usability is a major concern. We seek to offer a method that can be employed with minimum extension while realizing considerable benefits.
- Their interest in information is broad. The ability to drive information gathering is vital, in both restricted gathering of distinct information and events triggering new initiatives.
- Their open and inclusive practice is problematic. Proposing a method is confined to a precise set of goals. For instance, we excluded practices having satisfactory fulfilment in current EAM frameworks. And we excluded techniques that gather unnecessary data.
- They lack consideration of specific practices to deal with changes within EA models maintenance. The ability to improve the level of responsiveness of data maintenance is crucial (Ahlemann et al. (2012); Hauder et al. (2012)).
- Their proposals include a large set of new terminology. We propose a method supported by an extension to the underlying meta-model: an existing set of terminology with a small number of additions.
- They commonly lack guidelines to encompass small proposals. The ability to incorporate these proposals has a noticeable impact on the applicable usage. In addition, this will not be comprehensive unless it starts with a comprehensive elicitation of base requirements (Ahlemann et al. (2012); Goethals (2005); Hauder et al. (2012); Ross et al. (2006)).

In Chapter (5), we describe thoroughly the full set of requirements to address the previous motives. In Chapter (6), we propose a number of techniques to drive the desired practices. Moreover, we offer an extended meta-model enabling the representation of the outcomes

of these techniques. Furthermore, we provide a set of guidelines to advise stakeholders on how to approach modelling an initiative in the context of changing elements.

1.3 Research Problem

This section describes the research problem and questions guiding the development of our solution. The abstract definition of the class of problems is offered throughout Chapter (2). We discuss how we progressed from the class of problems to solve a particular problem in Chapter (3). This was important for developing our assumptions of preliminary design into the actual conditions of practice through the use of technical action research.

EAM and the supporting technological infrastructure form a focal baseline determining the capacity of business behaviour in current enterprises. Therefore, EAM encourages all efforts at enhancing the alliance with stakeholders across all organisational units, including upper management. With the aim of realising this alliance, EAM builds, maintains, and examines a model of the existing state of EA. The model represents all constituents of EA and has to be continuously managed to reflect changes in progress. Different stakeholders from different backgrounds supply and demand information from the constantly developing EAM models. According to the literature, the management and maintenance of these EAM models can prove to be a major practical difficulty ([Ahlemann et al. \(2012\)](#); [Avgeriou et al. \(2007\)](#); [Wegmann \(2002\)](#); [Winter et al. \(2010\)](#)).

Facilitating the maintenance of these EAM models was the purpose of existing studies addressing manual activities of EAM. However, these attempts were focusing on a particular set of data sources. These attempts, as explained later in the related work, do not take into consideration the variations across different organizations in regard to changeability of information sources and particularly of the EA maintenance context, see Chapters (2) and (5). In our action research, we attempt to address these issues by offering a number of techniques facilitating the ongoing maintenance of EAM, see Section (6.5) in Chapter (6). The employment of these techniques relies on extending the underlying meta-model with constituents supporting the desired practices, see Section (6.3) in Chapter (6).

EAM has a number of key purposes, one of which is the progress of the application landscape. Application landscape management has a number of challenges. The planning features of business support progress are considered to be well addressed by EAM frameworks. However, a focal challenge occurs in the representation of stakeholders' decisions, as it governs the initiatives and dynamically transforms the application landscape ([Garg](#)

et al. (2006); [GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Matthes et al. \(2008\)](#); [Van der Torre et al. \(2006\)](#)). Stakeholders' decisions mainly originate from the implicit business behaviour reflecting the diverse understanding of stakeholders, i.e. their isolated mental models.

We examine the aspects that support landscape management in relation to the scope of our problem, which we extracted from industry and the literature, see Chapters (4) and (5) for more details. We gathered part of these aspects based on the analysis and examination of the literature as well as from EAM technical reports. Thus, we try to highlight the absence of support for this challenge, as it has a direct impact on the handling of dynamism in EAM. In addition, it needs to be known that many solutions in the literature for application landscapes are modelled using tools of EAM that have no industry participation. Therefore, we first concentrate on integrating these aspects into a meta-model, bearing in mind the EAM frameworks modelling languages, see Chapter (6). Second, we attempt to examine our solution with practitioners from industry, see Chapter (7).

Numerous stakeholders participate in modelling the EA landscape. One of the key obstacles towards better responsive representation of the EA landscape is the collective understanding of business behaviour among all participating stakeholders ([Van der Torre et al. \(2006\)](#); [Weiss et al. \(2013\)](#)). Designing multiple states of EA landscape is a central part of EAM ([Buckl et al. \(2009b\)](#)). Therefore, the significance of joint thinking among stakeholders designing the EA landscape is apparent. The ability to support current practices with a means to model business behaviour and distribute this modelling across stakeholders is important. Business behaviour includes implications of business embedded actions and choices. This part of our solution aims to support current practices with guidelines to model and distribute the implicit business behaviour, see Section (6.4) in Chapter (6).

1.3.1 Research Question

- Research Question: Can an adapted or extended EAM framework be developed to deal with the dynamic business behaviour of an enterprise?

The ability to answer our research question is driven by realizing the following three precise questions:

1. By what means can we ideally support the constant stakeholders' need for information that is governed by the particular business behaviour/context of their enterprise? Our solution addresses concerns related to this question in Sections (6.3, 6.5) in Chapter (6).

2. By what means can we ideally enable building EAM models reflecting constant change in business behaviour and goals, and consequently improving the planning of target EA states? Our solution addresses concerns related to this question in Section (6.3) in Chapter (6).
3. By what means can we ideally produce an EA landscape reflecting the different mental models of stakeholders? Our solution addresses concerns related to this question in Section (6.4) in Chapter (6).

Section (6.1) in Chapter (6) outlines how these questions have guided the development of our solution.

1.4 Contribution

The objective of our research is to contribute to EAM frameworks' capacity to cope with business behaviour dynamics. As a result, we aim to identify crucial and practical areas of concern that directly affect EAM frameworks' ability to respond to changing internal and external elements, see Chapters (4, 5). Afterwards, we aim to design and develop a methodology extending the practices within these precise areas of concern. Finally, we aim to assess our solution's applicability and viability using an action case study. This means redefining and refining the solution parts. In the area of EAM, various approaches propose methods that each serve a particular objective, yet these approaches are principally isolated from one another. Therefore, we always consider the harmony of our solution with EAM frameworks.

The core contribution of our research:

- We propose a **methodology** for managing changing business behaviour, which adapts a number of techniques enabling enterprises to select the techniques best matching their contextual needs. This methodology relies on the capacity offered by our extended meta-model.

Summary of the Introduction Chapter

This chapter described the scope and main issues of the research. The first Section (1.1) of this chapter introduced the terms that are central to the scope of our research, while Chapter (2) documents the literature review related to the scope of our research. The second Section (1.2) presented the motivation driving our research. The motivation guided the decisions affecting the design of our methodology, see Chapter (3). The third Section (1.3) introduced the research problem and questions. Further explanation on the research problem is presented in Chapters (2) and (3). The fourth Section (1.4) of this chapter identified the contribution of this research. We describe how we reached that contribution in Chapters (4), (5), and (6). The evaluation of our proposed solution is presented in Chapter (7).

Chapter 2

Literature Review

In this chapter, the first Section (2.1) describes briefly the area of enterprise architecture, its main terms, and gives an introduction to what an enterprise architecture management (EAM) framework implies. The second Section (2.2) offers descriptions of a number of EAM frameworks. The third Section (2.3) discusses the issues that motivated our selection of TOGAF as the basis of our solution. The fourth Section (2.4) offers an outline of the research area.

2.1 Enterprise Architecture (EA) Definition

The beginning of this section states a number of Enterprise Architecture (EA) definitions. The following two subsections will provide an overview of enterprise architecture. The first subsection (2.1.1) will first present the main terms of enterprise architecture. Then, the ideal features of an EAM framework will be described, supplemented by the qualities that ensure that these features are present in any EAM framework. The second subsection (2.1.2) will offer a description of outcomes expected from employing an EAM framework. Afterwards, potential difficulties associated with the introduction of an EAM framework will be presented.

Many governmental ([Council \(1999\)](#); [US Department of Defense \(2010\)](#)), standardization ([The Open Group \(2009b\)](#)), technological, academic ([Buckl et al. \(2008\)](#); [Kurpjuweit and Winter \(2007\)](#); [Lankhorst \(2009\)](#)) and business authorities have defined enterprise architecture. Every single authority has defined EA and proposed an approach to manage EA. There is no one definition that everyone agrees on. However, they are widely united about

the structure of the main constituents and the overall purpose of enterprise architecture. Here are the most important definitions.

- According to META-Group, EA is *‘the holistic expression of an organisation’s key business, information, application and technology strategies and their impact on business functions and processes. The approach looks at business processes, the structure of the organisation, and what type of technology is used to conduct these business processes’* ([META-Group \(2002\)](#)).
- The US Federal CIO Council has defined enterprise architecture as *‘a strategic information asset base, which defines the business mission, the information necessary to perform the mission, the technologies necessary to perform the mission, and the transitional processes for implementing new technologies in response to the changing mission needs’* ([Government-wide Improvement \(2005\)](#)).
- The Open Group has stated that *‘Enterprise architecture consists of defining and understanding the different elements that make up the enterprise and how those elements are inter-related’* ([The Open Group \(2009b\)](#)).
- Zachman has defined EA as *‘the set of representations required to describe a system or enterprise regarding its construction, maintenance and evolution’* ([Zachman \(1999\)](#)).
- *‘Enterprise architecture is a relatively simple and straightforward model, framework, or template that can be used by everyone within your enterprise to assess how things are going, to facilitate their work, and to design new projects’*, according to [Egan \(1988\)](#).
- *‘Enterprise architecture is a complete expression of the enterprise; a master plan which acts as a collaboration force between aspects of business planning such as goals, visions, strategies and governance principles; aspects of business operations such as business terms, organization structures, processes and data; aspects of automation such as information systems and databases; and the enabling technological infrastructure of the business such as computers, operating systems and networks’*, as explained in Schekkerman’s book ([Schekkerman \(2006\)](#)).

2.1.1 Main Terms in Enterprise Architecture Management (EAM)

ARCHITECTURE is a term that describes the structure of elements or components defining a system. In addition, it describes the associations between these elements. It also includes the rules guiding the design of the structure and its development.

An ELEMENT is a constituent under the subject of technology, stakeholders, processes, and business. Instances include business goals, enterprise units, applications, and infrastructure. Furthermore, high-level hardware components can be an instance of an element.

ENTERPRISE is any set of organizations with one foundation and/or with shared objectives. Under this definition, a unit within an organization can be an enterprise; also a group of organizations with shared goals can be an enterprise.

BASELINE *current* enterprise architecture depicts the current state of the enterprise using several means. It is also called *As-Is* enterprise architecture. The state encloses the technological infrastructure and the existing business activities.

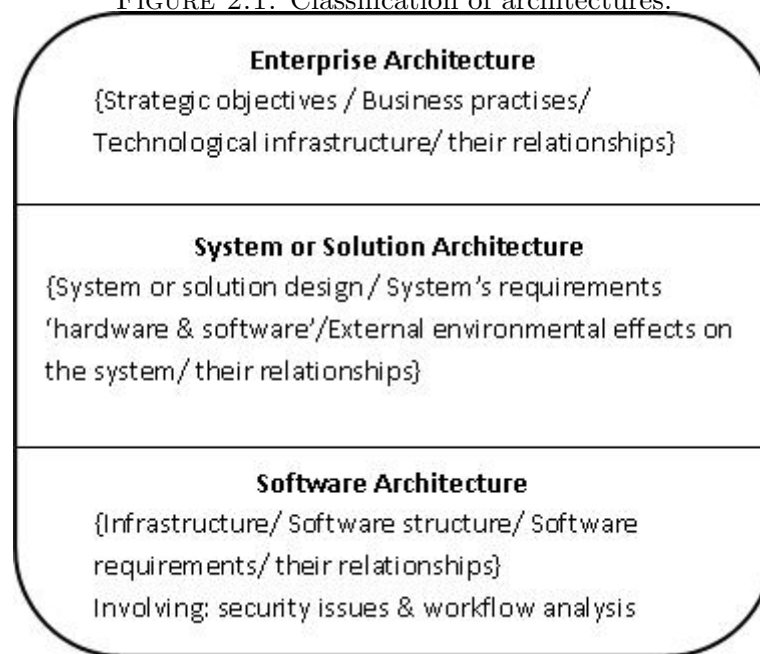
TARGET *future* enterprise architecture depicts the upcoming state of the enterprise. It is also called *To-Be* enterprise architecture. The state is derived from enterprise objectives and plans for business and technology. It shows the effects on the enterprise infrastructure and business practices.

TRANSFORMATION PLAN describes the utilized practice to transform the current EA to the target EA. An example is different scheduled activities, which can be simultaneous or interreliant. In addition, it illustrates gradual stages of the progress. It is also called a sequencing plan. The transformation plan takes a document form.

EA RESULT includes all means utilized to illustrate the enterprise structure and its external environment, involving all models, charts, and different representational descriptions. They are also called EA products.

There are several kinds of architectures covering different aspects of an enterprise. The classification of the main distinct architectures is provided in Figure (2.1). Shared aspects exist amongst different architecture kinds. They all utilize models expressing structures of different elements. They all aim to ease communication and analysis about elements represented in their structure. New architecture perspectives are rising to concentrate on specific aspects of an enterprise, such as security. A successful EAM should generate an architecture comprising the following features:

FIGURE 2.1: Classification of architectures.



1. A shared image of the target state of the enterprise should be sustained amongst business and IT to maintain the alignment between them. The strategic business objectives must be reflected in the target architecture.
2. A good representation of the enterprise is achieved when there is no need to remove any element from the architecture, while additions can be made during future development stages. Changes can be added if the structure is kept simple to a certain degree.
3. In the architecture, connecting external bodies should facilitate delivery of clients' requirements quickly.
4. Maintaining a technological understanding of the enterprise's needs and capabilities should help to ensure a good response to changes.
5. It is useful to merge and link different business processes in the enterprise. A thorough representation of the enterprise's state will clarify where different processes should be modified.
6. A good enterprise architect must ensure the availability and consistency of information. Resources should not have any level of overlapping, such as in different technologies, applications, and knowledge. Instead, the reuse of these resources should be enhanced.

The realization of the previously mentioned features requires an EAM framework ensuring the following qualities.

- An EAM framework should not only be inwardly centred. It has to cover all sides of the extended enterprise, in order to consider stakeholders, standardization, governmental, and business bodies that have influence on the enterprise. In short, an enterprise architecture should be holistic in scope.
- Another important quality of an enterprise architecture is that it should be established collaboratively. This means that representatives from all stakeholders, with different perspectives, should participate in building the EA. The represented alignment between business and IT should be understandable and visible to all stakeholders.
- In addition, EA should be a way to show the business value from applying the proposed solutions. Analytical methods should be offered by EAM frameworks to maintain the evolution of EA over time. Suggested solutions must be accompanied by means to evaluate, test, and reflect them to the facts on ground. However, an argument can be made that this feature might increase the complexity of EAM and exceed its domain.
- EAM frameworks should not make any assumptions about the use of a specific implementation approach ([Schekkerman \(2006\)](#)).

EA will be described in different architectural representation levels. The degree of an element's details described in different architectural representation levels should reflect the general aims intended by the architectural description. The key aims concentrate on accomplishing the alignment, cooperation, validation, and risk analysis. The details should not attempt to cover everything that exists. However, the level of detail should enable the design of holistic enterprise architecture, which accomplishes the required purposes of this architecture. The previous points should be the measure of a good EAM framework that can be adapted to different business domains ([Schekkerman \(2006\)](#)). Different architectural representation levels usually follow the classification of key four layers, which are defined in the following list.

- BUSINESS LAYER describes business activities, duties, associations, and structure. The degree of an element's detail at this level is limited to the point where their technological requirements can be determined. In addition, the described details must enable the evaluation of business performance.

- INFORMATION LAYER description should enable the identification of the needed security features and information interchange. It defines major information qualities to the business and to information flows. The extent of this detail must enable the identification of similar qualities and relations, to bring them into line with the whole architectural representation.
- INFORMATION-SYSTEMS LAYER describes the needed solution's design, characteristics, and functions. The degree of detail in this level should be in harmony with the previous two layers.
- TECHNOLOGY INFRASTRUCTURE LAYER does not define how offered technological services are implemented. It just defines the provided services.

2.1.2 EAM Frameworks

The development of EA needs to be managed structurally rather than using habitual management methods. Indicating the significance of EAM, a number of frameworks have been offered for initiating an EAM in an enterprise. They were offered by research institutes such as [Buckl et al. \(2008\)](#), experts such as [Zachman \(1999\)](#), governmental authorities such as [Council \(1999\)](#), and [US Department of Defense \(2010\)](#), and standardization groups such as [The Open Group \(2009b\)](#). The constituents of these frameworks differ in terms of suggested models, languages, and structure. According to the open group architecture framework (TOGAF), an EAM framework is *'a tool which can be used for developing a broad range of different architecture descriptions'* ([The Open Group \(2009b\)](#)).

EAM frameworks offer a managing method structuring and representing all elements, systems and technological infrastructure within an enterprise in a manner that outlines their association. The method is supplemented with tool-support and unifying terminology. Any EAM framework comprises guiding standards and varying products for different scenarios of possible employment. The structure and representation is commonly categorized and offered as building blocks. ([Boh and Yellin \(2007\)](#)). There are a few outcomes expected from employing an EAM framework:

- It should ease decision-making and analysis of development states. In addition, it will be a key information asset to facilitate reforming the enterprise.
- Another advantage is an instantly obtainable documentation of the enterprise.

- An additional benefit is the ability to foresee the predictable condition of the enterprise due to the reduced complexity of knowledge. This is achievable because business functions are incorporated with all related information throughout the enterprise.
- Development solutions are provided faster with lower costs, due to growing reuse of the enterprise's resources. Decisions to reuse certain resources can be made easily with the existence of holistic EA.
- An additional advantage is the preservation of a widespread anticipated visualization of the enterprise, between technological and business parties.
- EAM charts technological development activities within an enterprise and visualizes the activities' roles in accomplishing the enterprise's objectives. This enables enterprises to identify inconsistencies and limitations.
- Systems and Software consortium has stated that '*an Enterprise Architecture relates organizational mission, goals, and objectives to work processes and to the technical or IT infrastructure required to execute them*' ([Systems and Software Consortium \(2005\)](#)).

There are many difficulties associated with the introduction of EAM in an enterprise:

First, neglecting existing initiatives in the enterprise is a common weakness of the structured evolution of EAM frameworks.

Second, EAM frameworks do not usually provide a base from which to start building the framework. Architects usually start with eliciting the requirements to initiate the architecture. Therefore, eliciting the requirements from individuals and bodies, without guidance, will produce data exceeding the needs of the framework. For example, asking a stakeholder about their needs may lead to a list of wishes rather than concrete requirements, affecting the enterprise's productivity.

Third, most existing frameworks can only be employed as a whole. This is detrimental because a framework can be too broad to cover matters exceeding an enterprise's needs, or it can be too abstract. The lack of gradual introduction of the framework is another common aspect; if gradual introduction is possible, the framework will be more adapted to an enterprise's maturity.

Fourth, choices taken throughout the managed evolution of EAM need to be documented. This is essential in order to ease the expansion of EA; an instance of these decisions is why particular agents should participate in certain processes.

A study by the Institute for Enterprise Architecture Developments has stated that EAM is a top concern to chief executive officers and chief information officers (Lillehagen and Karlsen (2003)). Fast and major developments in technologies add to the confusion that top management faces when they choose a solution matching their requirements and resources. These offered solutions have many points of overlapping and overstatements; the same can be said about different standards enforced on an organization. This will add to the complexity of the decision-making process. EAM will help an enterprise to realize consistent and realistic knowledge about its environment. For instance, top management in an advertising company will be able to identify their rewarding markets and check if the enterprise's current resources are sufficient to meet existing clients' requirements. In addition, improved services' requirements can be identified, such as new systems or technologies.

A principle in designing an enterprise architecture is to design with the awareness that there are many unknowns, such as new technologies and environmental matters. This sophistication of planning enables the enterprise to accommodate new changes. Another key principle is the continuous consideration of the enterprise's broader context, such as outer environmental factors. EAM would not attempt to foresee the future but to provide the capability to adapt to any potential changes. Because it is impossible to take into account all potential upcoming changes, Schekkerman has urged EAM to be derived from an enterprise's strategic vision, stating that *'this vision bridges the extant status of the firm **where it is?** and its projected future status **where it wants to be?**'* (Schekkerman (2006)).

2.2 Overview of Dominant EAM frameworks

There are a number of existing EAM frameworks that vary in how extensively they are described and discussed in the literature. In this chapter, we will not describe and concentrate on all EAM frameworks. Some of them are similar and some of them are considered more important than others. Some approaches towards EA can be considered EAM frameworks as long as they fulfil satisfying concerns for describing and managing EA (Urbaczewski and Mrdalj (2006)). Therefore, we present a number of reference models, standards, and conceptual paradigms towards EA, even though some literature does not classify them as holistic EAM frameworks.

EAM frameworks can be distinguished depending on their approach towards what the term enterprise implies ([Tang et al. \(2004\)](#); [Urbaczewski and Mrdalj \(2006\)](#)). Classic EAM frameworks focus on representing a single centralized enterprise, while federated EAM frameworks focus on representing a number of enterprises, or structures that fit the meaning of an enterprise, and integrate them within a holding enterprise ([Urbaczewski and Mrdalj \(2006\)](#)). According to this, Classic EAM frameworks include the following frameworks: [Zachman \(1999\)](#), Kruchten 4+1 View Model ([Kruchten \(1995\)](#)), IEEE 1471 ([Hilliard \(2000\)](#)), Soni, Nord, and Hofmeister ([Hofmeister et al. \(2000\)](#)), [Tapscott and Caston \(1993\)](#), ISO's RM-ODP ([Vallecillo et al. \(2001\)](#)), and OMG's Model Driven Architecture ([Kleppe et al. \(2003\)](#)).

Federated EAM frameworks include: The Open Group Architecture Framework (TOGAF) ([The Open Group \(2009b\)](#)), the Federal Enterprise Architecture Framework ([Council \(1999\)](#)), C4ISR Architecture Framework ([C4ISR Architecture Working Group and others \(1997\)](#)), and the Treasury Enterprise Architecture Framework ([Systems and Software Consortium \(2005\)](#)).

Additional frameworks, which are discussed in our literature review, include The Ministry of Defence Architecture Framework ([Biggs \(2005\)](#)), Gartner Framework ([Gartner \(1985\)](#)), ARIS framework ([Scheer and Nüttgens \(2000\)](#)), The Generalised Enterprise Reference Architecture and Methodology ([Taskforce, IFIP-IFAC \(2003\)](#)), and The Extended Enterprise Architecture Framework ([Schekkerman \(2004\)](#)).

The following three subsections are descriptions of three main EAM frameworks: Zachman Framework for Enterprise Architecture ([2.2.1](#)), Enterprise Architecture Management Pattern Catalog (EAMPC) ([2.2.2](#)), and The Open Group Architecture Framework (TOGAF) ([2.2.3](#)). These three frameworks are distinctive in their approach towards EA. We focused on describing and comparing these three frameworks as they represent different classifications of EAM frameworks, see subSection ([2.2.4](#)). Zachman is a type of Classic EAM frameworks. TOGAF is a type of Federated EAM frameworks. EAMPC is a new type of approach to EA. The structure of the three frameworks will be explained. The key terms in these frameworks will be defined. In addition, the identification of their key features, goals, and nature will be offered.

The following subsections offer an overview of a number of approaches to EA. Subsection ([2.2.5](#)) offers an overview of The Reference Model of Open Distributed Processing (RM-ODP). Subsection ([2.2.6](#)) presents a description of IEEE 1471. Subsection ([2.2.7](#))

outlines the definition of Department of Defense Architecture Framework (DoDAF). Subsection (2.2.8) offers an overview of Federal Enterprise Architecture Framework (FEAF). Subsection (2.2.9) presents a description of Model Driven Architecture. Subsection (2.2.10) outlines the definition of Treasury Enterprise Architecture Framework (TEAF). Subsection (2.2.11) offers an overview of Kruchten's 4+1 View Model of Architecture.

2.2.1 Zachman Framework for Enterprise Architecture

John A. Zachman first issued his enterprise architecture management framework in 1987 (Zachman (1999)). He is regarded as the main innovator in the field (Schekkerman (2006)). Zachman has stated that the increased complexity of enterprises, and the continuous change, are imposing the need for a structured expressive representation (the enterprise architecture) (Zachman (1999)). Zachman's framework aims to look at information systems within an enterprise and the enterprise as a whole from distinct viewpoints. It aims to offer a view showing the relationships between all participating entities. It is a classification technique of an enterprise's architecture. Zachman framework is classified in terms of understandable decomposition of information by participants and by basic questions.

The Zachman framework has been utilized in several well-known enterprises, such as General Motors, Bank of America, and Volkswagen (Loche (2003)). Zachman initially realised that various parties will be involved to control the development of an enterprise. In the early stages, Zachman's thoughts were directed towards the development of information systems only. Concerns of stakeholders will vary from high-level business ideas and requirements towards low-level technological needs. Zachman has clarified one main principle: the team that is building EA should know that the produced EA will be affected by their perspective and from their objectives in building the EA (i.e. what they are looking to attain from EA).

The next section will offer a description of the Zachman framework. First, it will define how this framework would view an enterprise architecture. Second, a description of Zachman's suggested matrix will be provided. This will be supported by explaining cells' definitions, distinct stakeholders viewpoints and potential utilization ways.

2.2.1.1 Zachman Structure

The framework proposes six perspectives pointing out how an enterprise representation should be viewed. Zachman has named them as the following: Planner, Owner, Designer, Builder, Subcontractor, and User. The Zachman framework offers a scheme that utilizes

the integration of two categorizations. The first is the basic questions composing the ground rules of communication: what, how, where, who, when, and why. The combination of the outcomes of these inquiries will form the inclusive description of complicated thoughts. The second categorization is based on the transformation from abstract presentation into more detailed ones. The second categorization will be in line with the proposed six perspectives.

The integration between the two categorizations will form a six-by-six matrix, where the columns represent the first categorization and the rows represent the second categorization, see Figure (2.2). The intersection between the two categorizations is represented on each single cell. Every cell is distinctive; it is where an abstraction is represented and where the cell context prescribes the implication of the models' description. Two abstractions are represented on each cell, an abstraction of a *thing* and an abstraction of a *relationship* (Zachman (1999)).

The flow from the first row to the last row imitates the course of transforming a general thought into reality. Consequently, each row stands for the following: identification, definition, representation, specification, configuration, and instantiation. It can be seen that the top three rows represent business matters, while the bottom three represent technological matters. Zachman sees this as the main composition for enterprise architecture, where a framework can include the complete group of expressive descriptions related to an enterprise.

The Zachman framework is an ontology which properly symbolizes knowledge within an enterprise as a set of components. In addition, it symbolizes the relationships between these components. Zachman framework considers the unambiguous expressiveness of an enterprise, as an essential condition to run and revolutionize that enterprise. Zachman states that his framework is only the ontology depicting the enterprise, isolated from the methodology guiding the transformation. The existence of this ontology will enable applied processes to be predictable and to generate replicated outcomes. The framework concentrates on guaranteeing that the views are properly established to offer a comprehensive representation, by describing the purpose of different views. The framework states that it does not matter in which order different views are created.

Various perspectives of the various stakeholders participating on the development of EA will be reflected on one dimension of the framework, see Figure (2.2). Zachman stated that a group of architectural representations is sufficient to develop simple products, such as a new building. However, there is a need for a more sophisticated representation to match the level of complexity of an enterprise (Zachman (1999)). Therefore, Zachman suggested

the use of five architectural representations aside from the functioning systems. Each one of them will be placed on a single row.

FIGURE 2.2: Zachman Framework ([Sowa and Zachman \(1992\)](#)).

	Data (What)	Function (How)	Network (Where)	People (Who)	Time (When)	Motivation (Why)
Scope (Ballpark View)	List of things important to the business	List of processes the business performs	List of locations in which the business operates	List of organizations important to the business	List of events / cycles significant to the business	List of business goals / strategies
Business model (Owner's view)	e.g. semantic model	e.g. business process model	e.g. business logistics system	e.g. work flow model	e.g. master schedule	e.g. business plan
System Model (Designer's view)	e.g. logical data model	e.g. application architecture	e.g. distributed system architecture	e.g. human interface architecture	e.g. processing structure	e.g. business rule model
Technology Model (Builder's view)	e.g. physical data model	e.g. system design	e.g. technology architecture	e.g. presentation architecture	e.g. control structure	e.g. rule design
Detailed Representations (Subcontractor)	e.g. data definition	e.g. program	e.g. network architecture	e.g. security architecture	e.g. timing definition	e.g. rule specification
(Functioning system)	(e.g. data)	(e.g. function)	(e.g. network)	(e.g. organization)	(e.g. schedule)	(e.g. strategy)
Descriptive model	Entity Relationship Entity	Input Process Output	Node Line Node	Organization Reporting Organization	Event Cycle Event	Objective Precedent Objective

The first row is concerned with the scope depiction, to cover the most general consideration aspects of the scope, magnitude and shape.

The second architectural representation is focused on representing the requirements to achieve business goals. These requirements are extracted from high-level stakeholders, in order to understand the perspective of people setting out the goals. This row is called the business model ‘owner’s view’.

The third architectural representation contains the translation of the previous business model; it is called the system model ‘designer’s view’.

The fourth row associates the system model with reality, by introducing constraints of any nature, such as applicable technologies. It is called the technology model ‘builder’s view’. The last three architectural representations are vital because every single one shows stakeholders usually isolated from each other. The isolation will be minimized through deep expressiveness.

The fifth row is directed towards real implementation acts. However, it does not represent the inclusive functioning product; it represents certain parts of the overall structure. It is called ‘detailed representation’ or ‘subcontractor’s view’. Every single architectural representation includes a distinct group of constraints, which will be accumulative from one model to the next. Therefore, constraints from different models have to be consistent. Zachman has encouraged designers, supervising the whole process, to detect any such weaknesses between different models and even rebuild some models to maintain the consistency. The previously described five models can be seen in the succession of rows in Figure (2.2).

The sixth row in the framework aims to present another perspective, which is an architectural description of the real functioning system from a user’s perspective. However, experience shows that it is more than a depiction but physical objects (Loche (2003); Sowa and Zachman (1992)).

Various functional aspects need to be considered to formally describe an enterprise. The first aspect manages what units the enterprise deals with from every different perspective. The second aspect is concerned with how the enterprise will work on each level of technological detail. The third aspect is where different systems of the enterprise are placed. The fourth aspect is who participates on particular objects at any level of the enterprise, including individuals and business units. Why are certain activities made and why are they important. This is another aspect. The fifth aspect is when certain actions and decisions need to be made.

Zachman has realized that different functional aspects require a distinct nature of their descriptions. Therefore, the second dimension of his matrix is designated to the earlier aspects; each of them is presented in the sequence of columns. For each question, Zachman has suggested a primitive descriptive model. As seen in the final row of Figure (2.2). These models are initiated based on which viewpoint a person is looking at the enterprise. These descriptive models are respected and considered in each cell of that column, varying according to different perspectives on different columns. Three examples are provided next, to exemplify the contents of two columns and a row.

The first example attempts to clarify the use of these descriptive models. The suggested descriptive model for the ‘What’ column is ‘Entity Relationship Entity’, see Figure (2.2). The scope representation will contain a documentation of all entities significant to the business. The following cell in the owner’s view will offer a diagram showing participating entities and their relationships. The relationships will indicate constraints and business rules, for instance, the number of devices that can be bought by a single customer. The

next cell in the designer's view will contain another view on entities, in order to relate what is planned to reality, for instance, entities as records associated with data relationships. Then, the choice of which system to be used is made on the builder's view; here it will be determined what kind of database will be used. The type of representation is determined too, such as considering relationships as keys. For this example, SQL is presented in the subcontractor's view; Structured Query Language (SQL) is a 'standardized language for defining and manipulating data in a relational database' (Bowman et al. (1996)).

The second example for the content of the 'Who' column is provided here. The first cell can contain a list of all participants in any activity related to the enterprise. The second might represent the participants in charts, and how their productivity is associated. The third cell could depict a human interface architecture that shows the roles and deliverables of participating parties. The fourth cell can contain a graph detailing the users of the technology and their jobs. The fifth cell can describe the identity of the system's users and their authorities on identified transactions.

The third example is provided for a sequence of cells in the same row, 'scope'. The 'scope' row usually attempts to explicitly clarify the business drivers and needs originated from outside the enterprise, in addition to describing the business functions. The first cell in the row can contain a list of all units concerning the enterprise, such as products, markets, and services. The second cell could provide a list of all functions done by the enterprise, such as manufacturing, marketing, and designing. The third cell would include a documentation of all business locations, such as branches and warehouses. The fourth cell could list all events and meetings aligned with certain functions, such as schedules of projects. The fifth cell would contain a list of institutes affecting the enterprise, such as partners and suppliers. The sixth cell would normally enclose a documentation of high-level business goals.

The various stakeholders have different viewpoints on every distinct architectural representation. Therefore, the intersection between different descriptions and different viewpoints introduces Zachman's six-by-six framework. Every single cell in the matrix is unique and self-contained. At the same time, all cells are related with some type of connection. The grouping of all cells in a single row will provide an inclusive view of the enterprise from a particular perspective. In addition, as clarified in the earlier example, a cell needs to be aligned with the cells directly on top of and underneath it.

The Zachman framework offers a technique of classification that associates business matters to technological matters. The framework insists that it does not offer a single architecture for the whole enterprise, but rather a group of architectural representations that synthesize,

affect, and add to each other. The Zachman framework offers the utilization of suitable distinctive notations for every cell independently. However, Zachman attempts to persuade others to use a distinguished common language to represent the contents of all cells ‘conceptual graphs’ (Sowa and Zachman (1992)); Zachman suggested the use of that language in a further development of his framework.

There is not a single or an ideal way to start building the framework. However, there is a set of recommendations suggested to gain a proper representation. The order of the columns is not mandatory, but depends highly on the cause of initiating full architectural representations. On the other hand, the order of the rows is mandatory to go through a logical succession of perspectives, from a high-level business view down to a low-level technological perspective. It is recommended to start logically from the top left cell in the framework. The contents of cells might already exist in the form of documentation, schedules, process guides, or graphs. With or without utilizing the existing documentation, certain gaps will be found as one goes through the framework. Alignment has to be made and constraints need to be consistent. Identified knowledge requires being explicit to a larger number of participants. The classification scheme provided by the framework also aims to facilitate the retrieval of related information.

2.2.2 Enterprise Architecture Management Pattern Catalog (EAMPC)

An enterprise launching EAM will find that a variety of aspects are missing regarding the way the approach is specified. The majority of the concerns deriving from EAM are recurring in most enterprises (Buckl et al. (2008)). The core solutions for these concerns would offer a good base to guide the management of these concerns. Nevertheless, the core solutions should be presented in a way which enables the utilization of these solutions in different ways to handle the same concerns in different enterprises. In addition, the core solutions must be derived from best practices. EAMPC provides an EAM framework covering concerns that affect service management, business objects, architectural standardization, and application landscape (Buckl et al. (2008)). EAMPC is a set of methodologies that have time after time shown outcomes better than any other methods trying to address the same concerns. These methodologies are supplemented by information models identifying consistent terminologies, along with viewpoints for visualization.

Pattern is the main notion of EAMPC. A single pattern defines a common recurring concern and how this concern is influenced by different contexts and difficulties. Moreover, a

pattern describes the essence of the solution to the defined concern based on best practices. Yet, solutions will be offered in a general manner to be reused distinctively numerous times. A pattern identifies the connections between different contexts, where concerns are based. Their designated solutions are provided based on context at hand.

The next section will offer a description of EAMPC. First, it will define the three types of patterns in the catalogue. Second, EAMPC has identified a number of categories as a guidance through the catalogue, and these categories will be defined. Third, a description of the measures taken to manage the integration will be presented.

2.2.2.1 EAMPC Structure

EAMPC has proposed three types of patterns, see Figure (2.3):

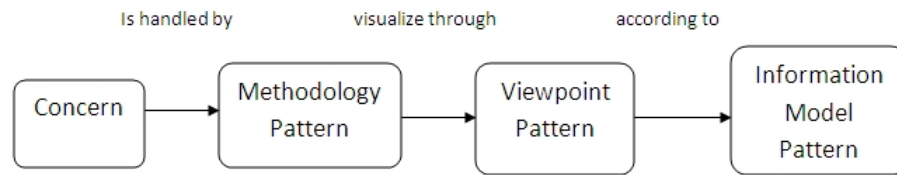
First, a **methodology pattern** identifies the followed procedure to deal with certain concerns. Anticipated contexts will be stated as guidance for applying procedure steps, combined with the concerns where these sequences of steps can be applied. The form of different procedures ranges from visual representation to any level of formalization. The explanation of all the steps in the methodology distinguishes this approach from other frameworks as they miss some details of a number of steps.

Second, a **viewpoint pattern** offers a description of how documented data should be viewed, along with ideal example views to ease the specification of viewpoints. Therefore, this pattern will offer a language utilized by a methodology pattern.

The Object Management Group (OMG) has established the Unified Modelling Language (UML) for representing architectures of different object-oriented software artefacts. OMG has proposed the Meta Object Facility (MOF) to facilitate the descriptions by other modelling languages. UML and the MOF are the core two of the four modelling layers of the Model-Driven Architecture (MDA) (Dsouza (2001)), see subsection (2.2.9).

Third, **information model patterns** provide the potential structures that would be represented in viewpoint patterns, i.e. a model of the language provided in viewpoint patterns. Different means can be used to describe an information model pattern, such as UML structures, MOF, or natural language.

FIGURE 2.3: Relationship between the Patterns of EAMPC.



An unlimited number of patterns can be proposed by different parties and individuals. However, only a certain number of these patterns will be considered, by the literature and expertise, to be valuable and related to the subject of EAM. EAMPC only considers the ones approved by the literature and expertise. In addition, patterns have to maintain consistent terms and an information structure in order to facilitate any form of integration and comparison. These patterns will be the core building blocks assisting the introduction of EAM in any enterprise. These building blocks will be adapted to fit existing concerns that any enterprise presently needs. Therefore, EAMPC *‘focuses on addressing specific concerns and does not build an all embracing model that is meant be used for all thinkable concerns’* (Buckl et al. (2008)).

This approach manages concern-driven and fully acknowledged information models. Furthermore, this approach disregards the customary holistic, generic, and major approaches. This point will lessen the need for immense efforts and costs to introduce EAM. The nature of this approach will enable continued enhancement and addition to the catalogue, in order to publicize documented best practices. Thus, any enterprise introducing EAM can access, select and adapt common concerns and their associated patterns. Furthermore, an enterprise can navigate through documented problems and solutions. This navigation is based on categories of EAM concerns offered by EAMPC.

EAMPC gathers and classifies problems and their solutions according to the following categories; *‘Technology Homogeneity, Business Processes, Application Landscape Planning, Support of Business Processes, Project Portfolio Management, Infrastructure Management and Interface, Business Object, and Service Management’* (Buckl et al. (2008)). Each category contains concerns and the procedures to tackle them regarding that particular topic of EAM.

- If the enterprise is faced with any matter affecting the uniform nature of infrastructure supporting the application landscape, then this enterprise can navigate through the Technology Homogeneity set of methodologies.

- Business Processes is the second category, which includes methodologies associated with any business issue at any level of abstraction.
- If there is a concern linked with the development or composition of the application landscape, then the enterprise can search among the Application Landscape Planning set of methodologies.
- A group of methodologies focusing on how IT sustains an exact business process can be found in a category called Support of Business Processes.
- Project Portfolio Management can be searched if there is a new project influencing the application landscape.
- Infrastructure Management deals with concerns of the technical infrastructure's influence on the relation between applications and business processes.
- All methodologies concerned with service oriented architecture can be found in the Service Management category, embracing communicated data and business objects.

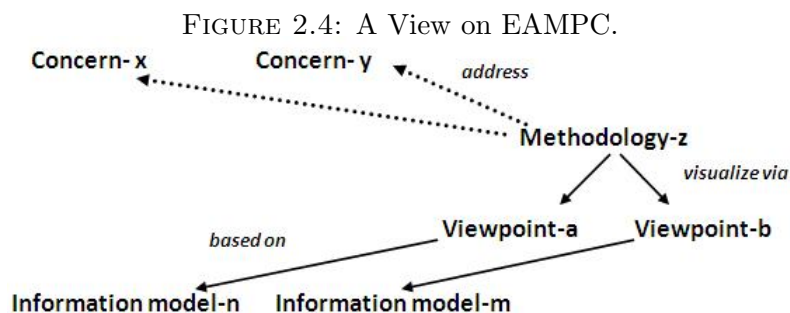
Different patterns can be initiated by various bodies. These patterns will be built on assumptions applicable within the scope of these patterns only. However, this will cause unacceptable discrepancy between various patterns, if an enterprise tries to concurrently enclose a set of patterns as an EAM approach. EAMPC takes certain measures to ensure that no conflicts or inconsistency will occur on the integration phase. Different steps are taken to ease a smooth integration of the three distinct types of patterns. This feature gives EAMPC an advantage over random patterns, which are not aligned with each other. The next three paragraphs will provide some highlights of aspects of pattern integration.

Integrating methodology patterns has to manage the assortment and interaction among a group of methodologies aiming to realize a group of concerns. A process model has to be identified to clarify the steps to be taken to control the EAM practice. One act demanded from the team launching EAM is to document all assumptions made about the procedure of each pattern. This will enable the integrator to consider these assumptions. These assumptions vary from the style of the communicated information to the accessible resources.

Integrating viewpoint patterns usually does not require much effort. This is due to the availability of exemplary viewpoints that guides how a single viewpoint should address certain concerns without any dependability on other viewpoints. This self-reliant nature of patterns will enable the generation of more abstract viewpoint layers.

Integrating information model patterns can be faced with a few difficulties especially if these patterns are originated from different sources. Familiarity with modelling techniques is a necessity for this integration. Second, originators must maintain consistent terms and information organization. Sensible naming must be supplemented with clear definitions of respective classes. The integrator must consider constraints on independent patterns to enable single ones to be implemented individually, for example, modifying multiplicities for a common class in different patterns.

EAMPC can be utilized in three different ways. First, it can be used as a radical turnaround to the organization through the introduction of EAM. This will be derived by the enterprise's concerns, thus navigating the list of concerns in the catalogue will be the starting point. Each concern in the list will refer to a methodology pattern that employs one or a few viewpoint patterns to visualize some aspects of EA, see Figure (2.4). The latter step will involve the reflection of some information model patterns. The final action is to integrate involved patterns into a customized EAM framework.



The second way to utilize EAMPC is to use it as a means to evaluate and improve an established EAM framework. This is done by examining and comparing best practices offered in the catalogue supplemented with concerns from real enterprises. For instance, the well documented steps and visualization examples can be utilized by other approaches. The elicitation of an enterprise's requirements can be inspired by thoroughly assessed and solved concerns.

The originators of this approach claim that it might also be used as the base for research in EAM. They state that the catalogue enables the accumulative development of patterns, rather than leaving each source to initiate their ideas from scratch (Buckl et al. (2008)).

2.2.3 The Open Group Architecture Framework (TOGAF)

The Open Group is a ‘*vendor and technology-neutral consortium with the objective to foster information flow via open standards for enterprises*’ (The Open Group (2009b)). The Open Group Architectural Framework (TOGAF) was originally derived from the US Department of Defence’s Technical Architectural Framework (The Open Group (2009b)). TOGAF was launched by The Open Group in 1995. TOGAF’s mission is to offer a framework to design, validate, and develop EA. TOGAF is well-known and widely used; therefore, key participants in the field have integrated TOGAF in their tools. Moreover, there is a TOGAF 9 method plug-in for the open source Eclipse Process Framework Composer tool, which is an advantage (The Open Group (2009b)). TOGAF concentrates on business activities that are essential to the enterprise’s objectives. TOGAF does not attempt to enforce a group of EA development principles but to offer a description of good ones.

TOGAF offers Enterprise Continuum, which is a repository containing architectural representations means, such as different models. In addition, TOGAF offers Resource Base containing the necessary guidance for the utilization of the framework, for instance, pre-examined templates. TOGAF states that ‘*enterprise architecture is about understanding all of the different elements that go to make up the enterprise and how these elements inter-relate*’ (The Open Group (2009b)).

In addition to TOGAF’s definition of EAM framework, as in Section (2.1), TOGAF also identifies two fundamentals of any EAM framework: the identification of products achieved from initiating the framework, and the EAM frameworks which could preferably describe how the initiation of the framework has to be completed, which is not offered by all frameworks (The Open Group (2009b); US Department of Defense (2010)).

The next section will offer a description of TOGAF. First, it will define the architectural development method (ADM) of TOGAF; this will include descriptions of its six core elements. Second, the ADM cycle will be explained, supplemented with a short definition of the nine phases of the cycle. Third, most of the extended features of TOGAF will be presented.

2.2.3.1 TOGAF Structure

TOGAF is formed from six core elements: ‘*architectural development method (ADM), content framework, enterprise continuum and tools, ADM guidelines and techniques, and two reference models*’ (The Open Group (2009b)).

First, ADM attempts to provide an iterative approach to managing the development of EA. This iterative approach involves the employment of an introductory phase followed by the appliance of eight interrelated iterative phases.

Second, the content framework is a conceptual metamodel, which is utilized to depict elements of the enterprise.

Third, enterprise continuum and tools offer an outlook on EA repository, which allows the reuse of offered descriptions and permits the restructuring of EA.

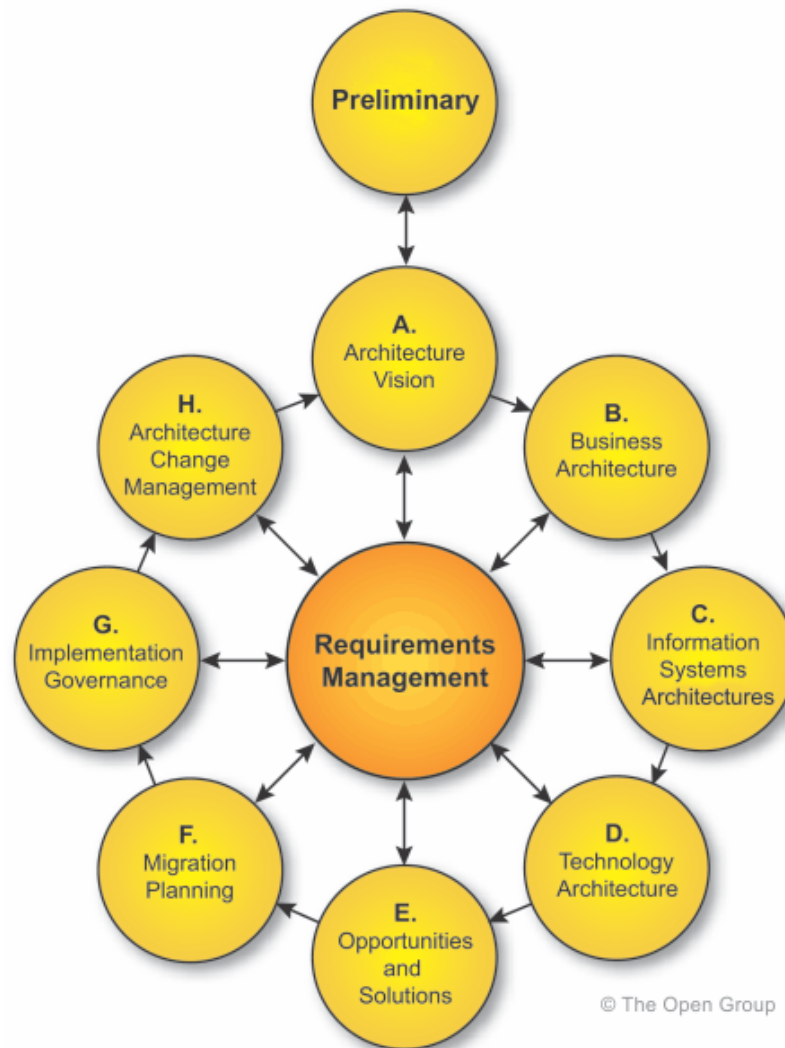
Fourth, ADM guidelines and techniques support the utilization of ADM, involving aspects such as adaptability, construction, and features of certain architecture domains. TOGAF reference models embrace the last two elements of TOGAF.

Fifth, the first reference model could be utilized to construct any architecture; it is called the TOGAF foundation architecture model.

Sixth, the second reference model deals with the demand to compose an infrastructure based on reference designs; it is called the integrated information infrastructure reference model. TOGAF's suggested structure is aligned with the rest of the EAM approaches regarding the distinctive viewpoints on architecture layers, as defined in Section (2.1): business, information, information systems, and technology infrastructure.

The architectural development method (ADM) is the key element of TOGAF. ADM mainly is what TOGAF is known for. ADM defines the nine phases proposed by TOGAF to develop EA, see Figure (2.5). Any group intending to introduce EAM should refer to these phases, by adapting these phases at different levels of the enterprise. ADM is an iterative generic approach to developing EAM. TOGAF offers guidelines to drive how the adaptation should be done, which is introduced in the ADM guidelines and techniques. However, this section needs extensions to provide more in-depth guidance ([US Department of Defense \(2010\)](#)). ADM does not impose commands on EA developers regarding the degree of details at different organization's levels or what elements should be covered at each level. It respects the fact that every specific enterprise can adapt the approach to their needs. However, this feature is not entirely specified and proved according to critics of the TOGAF ([Buckl et al. \(2011a\)](#)). The next section will describe the nine ADM phases:

FIGURE 2.5: TOGAF architectural development method as in (The Open Group (2009b)).



‘Preliminary framework and principles’ - This phase is used to identify the used framework and the rules guiding the development of EA, in order to underline the basis of architecture inside the enterprise. All activities in this preliminary phase are concerned with the groundwork and initialization of EAM. Issues considered in this phase include EA team, potential tools, and followed EA principles.

The ADM cycle consists of the next eight phases:

- **‘Architecture vision’** - This phase describes abstractly, without details, the baseline EA and the target EA, covering technical and business viewpoints. The scope of EAM’s effort will be identified. The key outcome of this phase is the identification

of related stakeholders and their interests. The business, information systems, and technology architectures are constructed during the next three phases respectively.

- **‘Business architecture’**, this phase studies the variance between baseline EA and target EA, concentrating on the business viewpoint.
- **‘Information system architecture’** - This phase attempts to recognize the needs related to information and applications in order to describe the desired architecture that satisfies these needs.
- **‘Technology architecture’**, this phase is very important and it requires huge effort to be completed. Eight steps are performed to provide the basis for developing EA. These steps are baseline creation, views selection, forming models, services choice, business objectives determination, criteria identification, architecture description, and accomplishing gaps investigation.
- **‘Opportunities and solutions’** - In this phase, implementation options are assessed and chosen. This phase attempts to align the three earlier architectures. In addition, this phase concentrates on deriving various initiatives; these initiatives demonstrate clearly the transformation nature from As-Is architecture to To-Be architecture. This shows the need to describe the transitional ‘planned’ architecture, showing the EA state with all approved initiatives.
- **‘Migration Planning’** - This phase studies different proposed initiatives. This phase checks any overlapping or reliance between initiatives, to determine their priorities. The current, planned, and target architectures outline the input to this phase. This phase plans the timetable to accomplish the intended architectures. A key contribution is to give each initiative a business value; this allows the prioritization of various initiatives in line with the proposed plan.
- **‘Implementation governance’** - This phase administers the implementation of initiatives, concentrating on what is called an architectural contract. Approved projects, which serve the realization of the intended architectures, will be implemented in this phase. A key outcome is the recognition of utilized resources and skills.
- **‘Architecture change management’** - This final phase is concerned with the constant observation of changes in the latest technology, performance targets, and business matters that might initiate further developments. It ends a cycle and arranges the launch of a new iteration.

‘Requirements management process’ is essential to every phase of ADM as it names, records, and communicates requirements with every one of them.

ADM is a broad method that deals with EA at all particularized different enterprise levels. Its approach maintains EA’s evolution by means of enterprise continuum, regarding it as its knowledge base. ADM phases describe properly the steps to be taken, but it allows EA developers, regarding implementation decisions, to adapt their needs and decide what the needed products out of this design are. TOGAF suggests that all decisions made regarding the design of EA be documented in order to allow the traceability of these decisions. TOGAF offers exemplary instructions and guidance to support ADM phases ([The Open Group \(2009b\)](#)), covering the following topics: architectural principles, data analysis, organizational contexts, and capability-based planning.

TOGAF has suggested three dimensions for segmentation in order to arrange the management essence of ADM ([The Open Group \(2009b\)](#)). The segmentation of EA can be done with reference to architecture depth, time, and scope. The segmentation of EA will be in reference to the included kinds of architecture, in respect to the architecture depth. The segmentation of EA will be in reference to the covered states of architecture ‘current, planned, and future’, in respect to time. The segmentation of EA will be in reference to business locations, functions, units, and participants. TOGAF points to the value of adapting the management essence, but TOGAF does not provide any means to carry out this configuration.

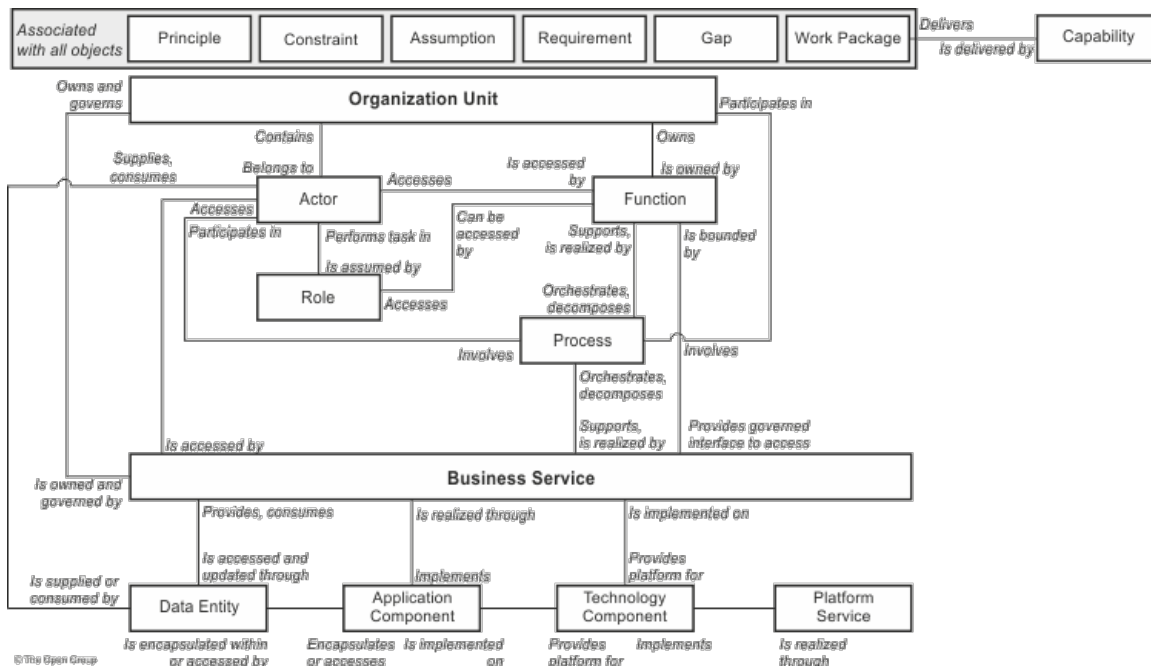
The technical reference model (TRM) depicts the system’s components and its services using units including application, application platform, and communication infrastructure; it is indicated by the enterprise continuum. TOGAF has proposed the use of many different views on the enterprise. The views are ‘*Business Architecture View, Data Architecture View, Application Architecture View, Technology Architecture View, System Engineering View, Enterprise Security View, Enterprise Manageability View, Enterprise Quality of Service View and Enterprise Mobility View*’ ([The Open Group \(2009b\)](#)). Enterprise Continuum also offers the ‘Standard Information Base’, which is a repository of information, regulations and standards, such as adaptation for designing architecture views ([The Open Group \(2009b\)](#)).

A meta-model of the enterprise contents is also introduced to enable the description of the enterprise architecture; it is called the TOGAF content framework. This meta-model is provided to illustrate which elements of an enterprise have to be considered. Many concepts that can be used to describe and document the enterprise are contained in this

meta-model, accompanied by a group of pre-identified relations and properties. Concepts covering all architectural layers are included in the core meta-model, as illustrated in Figure (2.6).

Furthermore, six additional meta-model extensions are introduced by TOGAF. These extensions are introduced to support the description of a number of divisions: governance, services, process modelling, data, infrastructure consolidation, and motivation. These extensions are supported by guidance on when to use them and what to expect from using them. Criticism is made against TOGAF, stating that the prescriptions of its information model are too abstract and lack the appropriate reflection of potential applied constraints and properties, even though some critics admit that some of these points were addressed after the introduction of the TOGAF modular structure in the new version (US Department of Defense (2010)).

FIGURE 2.6: TOGAF content framework ‘core metamodel’ (The Open Group (2009b)).



The Open Group issued a new version of TOGAF (version 9) in 2009 (The Open Group (2009b)). More features were launched to back the structure of EAM, directed to adapt for certain demands of a particular enterprise. The gradual introduction of the framework and enhanced usability were key factors to launch a modular structure. Comprehensive and detailed guidance was introduced to govern the process of EAM. In addition, a content framework, that enhances consistency, and architectural styles were introduced (The Open Group (2009b)).

2.2.4 Comparison of Three EAM Frameworks Representing Different Classifications

We have published a detailed analysis of the following three EAM frameworks as a part of a book about model-driven business process engineering ([Almisned \(2014\)](#)), here we provide a summary of the analysis. For the purpose of this analysis, an EAM framework is a tool utilized for initiating a wide variety of architectures, which enclose the required knowledge of an enterprise. This tool must offer means for retrieving, managing, and presenting the knowledge in the enterprise. In addition, it should define the outcomes expected from the practice, accompanied by an inclusive description of what needs to be performed to achieve these outcomes. The following analysis is based on the previously identified boundaries of an EAM framework. Generally, the analysis and comparison of different EAM frameworks are faced with obstacles regarding the different nature of intended usage and scope. Therefore, any analysis should identify the foundation of its comparison. This analysis will be based on distinguishing different EAM frameworks in regard to their focus area, perspectives, goals, inputs, outcomes, and abstractions, see Tables ([2.1](#), [2.2](#), [2.3](#)).

TABLE 2.1: An overview of Zachman Framework

Features	Zachman Framework
Issuing Organization	Zachman Institute / Proprietary framework
Issuing Date	1987
Tools Support	None
Centre of attention	Zachman mainly focuses on the area of modelling, with monolithic organization of knowledge
Perspectives	-Very clear and comprehensive -Capable of representing various views of different stakeholders -Could be the base of views classification and consistent terminologies offered by different frameworks
Goals	-It explicitly supports Architecture analysis and models. -It does not support Architecture process, evolution support, standardization, knowledge base and verifiability. -It partially supports Architecture definition, understanding, design tradeoffs and design rational.
Inputs	-It explicitly supports Business requirements. -It does not support Technology inputs. -It partially supports Business drivers, information system environment, current architecture and non-functional requirements.
Outcomes	-It explicitly supports Business, System, Information, Computation, and software processing models, in addition to platforms. -It does not support software configuration model, transitional design and design rational. -It partially supports Implementation model and non-functional requirements design.
Abstractions	-Two distinctive types of abstractions are only established in this framework, these two abstractions are represented in the when and why columns. They clarify the time and justification of system's features. -Zachman properly classifies the needed abstractions to offer a comprehensive look on the enterprise. What is needed to be presented is described. However, it is not supported with the required methodologies.

Comparison between different EAM frameworks can be done with reference to how each framework relates and covers the Systems Development Life Cycle. The widespread five phases of the cycle can be the basis of this comparison; these phases are planning, analysis, design, implementation, and maintenance. On the whole, EAM frameworks specify aspects of the planning and analysis phases, providing and supporting all views. On the other hand, the manner in which the system will be developed is not specified. EAM frameworks can be seen as the guidance that will be applied in the cycle. Therefore, EAM frameworks can be easily harmonized with the planning phase, whereas the majority of EAM frameworks fail to cover aspects of the maintenance phase. The Zachman framework appears to encompass all phases of the cycle except maintenance. Key publications for Zachman are ([Zachman \(1999\)](#)) and ([Sowa and Zachman \(1992\)](#)).

TABLE 2.2: An overview of TOGAF

Features	The Open Group Architecture Framework (TOGAF)
Issuing Organization	The Open Group / Consortia-developed framework
Issuing Date	1995
Tools Support	TOGAF 9 Method Plug-in for the Eclipse Process Framework Composer tool
Centre of attention	TOGAF mainly focuses on utilizing a driving method with explicit organization
Perspectives	- Perspectives are clear regarding Business Architecture View and Technical architecture views - Views are not distinctively directed towards the scope, subcontractor and user perspectives
Goals	- It explicitly supports Architecture analysis, definition, understanding, process, evolution support, standardization, knowledge base, verifiability, models and design rational. - It partially supports design tradeoffs.
Inputs	- It explicitly supports Business requirements, Technology inputs, Business drivers, information system environment, current architecture and non-functional requirements.
Outcomes	- It explicitly supports Business, System, Information, Computation, Implementation, software configuration and software processing models, in addition to platforms, transitional design and non-functional requirements design. - It partially supports design rational.
Abstractions	- The 'how' or 'functionality' abstraction is addressed with the guidance concerning the decision-making provided by TOGAF. - The 'who' or 'people' abstraction is addressed partially with the guidance concerning the IT-resources provided by TOGAF. - Other abstractions are not explicitly and thoroughly addressed, while generally the architecture principles guidance supports the representation of abstractions.

TABLE 2.3: An overview of EAMPC

Features	Enterprise Architecture Management Patterns Catalog (EAMPC)
Issuing Organization	Technical University Munich / Academia-developed framework
Issuing Date	2007
Tools Support	As this framework was derived from the software cartography project in the university. System cartography tool is provided
Centre of attention	EAMPC mainly focuses on utilizing patterns as the building blocks of EA, starting from concerns as the deriving points
Perspectives	- Perspectives are driven from the categories of different concerns. - The seven offered categories are classified according to EAM topics, however they can be matched with the six perspectives that are offered by Zachman.
Goals, Inputs, and Outcomes	EAMPC is based on the assertion that any required goal, input or outcome can be addressed by introducing a pattern that resolve any existing need.
Abstractions	- Since EAMPC is not a framework that is introduced as a whole; abstractions are not explicitly described. - Different methodologies and information models offer guidance on different abstractions required for enterprise's architectures.

TOGAF principles and guidance materialize aspects of the cycle's phases despite the lack of clear handling of maintenance. Aspects of the planning phase are not explicitly specified in TOGAF. TOGAF guidance and rules sustain decision-making, IT resources, architecture standards for planning, and performance. Next is an instance of how a single EAM framework's view can cover partial aspects of a phase in the cycle. The planner view in the Zachman framework will contribute by sketching a system that achieves core goals and by providing an inclusive view of the enterprise. These are some of the intended aims of the planning phase.

The majority of EAM frameworks propose suggestions about the representation of different abstractions. However, most of them do not offer the needed means and methodologies to represent these abstractions ([Schekkerman \(2006\)](#)). All three frameworks provide a description of the knowledge required by the framework. The distinction between these EAM frameworks is more observable regarding the utilized technology and the actual features of the framework, where various frameworks offer in-depth architectures, while some offer abstract architectures. For instance, to simplify the purpose of the 'who' or 'people' abstraction, all organizational associations affecting the functionality of the enterprise must be represented in this abstraction.

The features of business and technical architectures provided by TOGAF are an important advantage of the framework. Nevertheless, these architectures do not offer inclusive details on aspects of planning and continuity. The contributing process ADM of TOGAF adds a key advantage over other frameworks. *'The ADM of TOGAF thereby focuses on EAM initiatives instead of a continuous EAM function. While this approach ensures that a sponsor for the EAM endeavour is available (see preliminary phase), it entails the disadvantage that each project has to start with information gathering as no up-to-date information and description of the EA is available'* ([Buckl and Schweda \(2011\)](#)). The segmentation of EA can be done with reference to architecture depth, time, and scope. TOGAF points to the value of adapting the management essence, but TOGAF does not provide any means to carry out this configuration. Key publications for TOGAF are ([The Open Group \(2009b\)](#)) and ([Buckl et al. \(2011a\)](#)).

The distinction between EAM frameworks is observable regarding the framework's extent of details. Some EAM frameworks are abstract, such as Zachman, while others are very detailed, such as TOGAF. In contrast, EAMPC avoids this variation by eliminating the need to introduce the entire framework as a whole; as an alternative, patterns will be introduced incrementally, reflecting the maturity of an enterprise. A number of EAM frameworks can only be seen as suggested guidelines, while some EAM frameworks offer

processes and methods. The key publication for EAMPC is ([Buckl et al. \(2008\)](#)).

General terminologies are a feature of abstract EAM frameworks. Arguments can be made against abstract EAM frameworks due to the questionable soundness of the EAM framework's employment. The Zachman framework provides the most inclusive classifications and viewpoints covering different aspects of the enterprise, whereas a large number of EAM frameworks cover and represent fewer aspects using fewer viewpoints. EAMPC aims to counter the concern about complex frameworks by enabling the construction or alteration of one pattern independently. EAMPC design is intended for easier extension and development as it is designed to be open.

2.2.5 The Reference Model of Open Distributed Processing (RM-ODP)

RM-ODP was initiated to unite an organizing framework for the standardization of Open Distributed Processing (ODP). RM-ODP was introduced by the standards bodies: the International Organization for Standardization (ISO) and the International Telecommunications Union (ITU-T) ([ISO/IEC CD 10746-1 \(1994\)](#); [Vallecillo et al. \(2001\)](#)). ODP utilizes a shared interaction model to improve mixed distributed processing in and amongst enterprises. RM-ODP offers five viewpoints to describe the problems of ODP. The viewpoints are: technology, engineering, enterprise, computational, and information ([Vallecillo et al. \(2001\)](#)). They respectively define models for implemented systems, distributed systems infrastructure, policy analysis, distributed programming languages, and information analysis. RM-ODP describes concerns to improve integration between distribution, interworking, interoperability, and portability of ODP ([Vallecillo et al. \(2001\)](#)).

RM-ODP has three goals to fulfil between different ODP systems namely: portability, interworking, and distribution transparency. RM-ODP attempts to represent the constructs of an ODP system as a comprehensible picture. RM-ODP has no impact on the selected technologies and does not standardize the constructs of an ODP system. This can be an advantage owing to the flexibility of the implementation, but it can be a disadvantage, as it does not emphasize managing the integration of heterogeneous components of an ODP system; RM-ODP is abstract, but not vague.

The structure of RM-ODP comprises four parts: Overview and Guide to Use, Descriptive Model, Prescriptive Model, and Architectural Semantics. All four are part of series of recommendations named ISO 10746 and ITU-T X.900. RM-ODP supports common

ODP functions by presenting a big picture of pieces of ODP systems, especially functions addressing the requirements of computational and engineering language, such as trading and relocater functions. ISO and the ITU continue to complement this reference model, planning more exploitation of the industry groups (Stojanovic et al. (2001); Vallecillo et al. (2001)).

There are a number of discussion points on the practicality of RM-ODP:

- RM-ODP offers a high level of abstraction that may discourage enterprises from successfully developing ODP applications (Kilov et al. (2013); Stojanovic et al. (2001)).
- ODP is mainly adopted in industry for representing partial components of the utilizing organization by IT departments, an example of which is the utilization of some Swiss banks (Stojanovic et al. (2001)).
- There is a risk associated with building systems with RM-ODP due to its reliance on commercial tools support, such as CORBA (Kilov et al. (2013); Stojanovic et al. (2001)).
- RM-ODP aims to facilitate integration, but the expression of requirements in isolated languages depending on the viewpoints can complicate integration in practice (Kilov et al. (2013)).

2.2.6 IEEE 1471

IEEE 1471 is a Recommended Practice for Architectural Description of software-intensive systems (Hilliard (2000)). IEEE 1471 was introduced by the IEEE's Architecture Working Group, and was funded by the Software Engineering Standards Committee of the IEEE Computer Society. The goal of IEEE 1471 is to enable the representation and sharing of architectures between stakeholders as to architectural descriptions. IEEE 1471 initiates a conceptual model as a context defining terminology concerning the use of architectural descriptions (Emery and Hilliard (2008)).

IEEE has established a number of goals for the standard. First, IEEE 1471 should describe architectures of wide-ranging scope in order to be applicable to different interpretation by different systems. Second, IEEE 1471 introduces a unified terminology and conceptual framework. Third, it should distinguish comprehensive architectural practices. Fourth, it should enable commercial technologies to be in line with the evolved architectural practices (Hilliard (2000)).

IEEE 1471 comprises a number of elements. First, IEEE 1471 identifies the group of requirements for architecture description of software-intensive systems. Second, IEEE 1471 offers a conceptual framework that defines the contextual use of a number of key terminologies. Third, IEEE 1471 identifies these key terminologies as in system, system stakeholders, architectural viewpoints, architectural views, and architectural description. IEEE 1471 does not define or need the compliance of tools, enterprises, practices, or systems; it leaves such practices to other frameworks, such as TOGAF (Emery and Hilliard (2008)).

An architectural description comprises at least one viewpoint; the selection of these viewpoints depends on relevant stakeholders with concerns addressed by this particular architecture description. Concerns are defined as particular considerations affecting an aspect of the systems progress, for example: reliability, advancement, performance, and security (Hilliard (2000)).

IEEE 1471 encourages the use of viewpoints and provides a number of examples for a possible architectural description. IEEE 1471 offers discussions on the possible use of the standard within another industry-centred approach (Emery and Hilliard (2008)). IEEE 1471 encourages stakeholders to document all inconsistencies between architectural descriptions. IEEE 1471 instructs system stakeholders to identify and connect concerns to relevant viewpoints in order to be represented by models. However, the process driving such practice is left for respective stakeholders in order to offer flexible model development (Emery and Hilliard (2008)).

IEEE 1471 defines a viewpoint as the outlook guiding the modelling of an architecture view, including its method and constraints. The view is the all-inclusive representation of the system; it comprises at least one architectural model. A model can be part of a number of views. A model describes one aspect or more of the system using the identified methods in the relevant viewpoint. This would allow viewpoints to be independent of the system while views are particular to actual systems. Therefore, the selection of candidate viewpoints is made before the construction of views. IEEE 1471 obliges each architecture view to relate to just a single architecture viewpoint in order to support consistency as a requirement of IEEE 1471 (Hilliard (2000)).

IEEE 1471 has a number of concerns:

- IEEE 1471 assigned stakeholders with the task of identifying and connecting concerns to relevant viewpoints. This adds to the flexibility of the reference model but has a

risk of slowing the development process ([Avgeriou et al. \(2007\)](#); [Rozanski and Woods \(2012\)](#)).

- IEEE 1471 established terms for architecture descriptions but did not adopt a clear practice driving the definition of architectural models ([Clements \(2005\)](#); [Tang et al. \(2010\)](#)).
- IEEE 1471 is ideally complemented by an industry-supported framework. This is due to its nature where the requirements of IEEE 1471 are independent of any architectural technique. This offers a flexibility of employment but raises practicality concerns ([Avgeriou et al. \(2007\)](#); [Rozanski and Woods \(2012\)](#)).
- IEEE 1471 has emphasized its serving as a base for initiatives evolving the field. It has indeed encouraged academia to advance in research. However, it has not pioneered an all-inclusive framework commonly used for driving EAM in industry ([Clements \(2005\)](#); [Tang et al. \(2010\)](#)).

2.2.7 Department of Defense Architecture Framework (DoDAF)

DoDAF was initiated in 1990 under the name C4ISR, which stands for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance ([US Department of Defense \(2010\)](#)). DoDAF stands for the US Department of Defence Architecture Framework. DoDAF offers a basis of three groups of views: Operational, System, and Technical ([US Department of Defense \(2010\)](#)). DoDAF associates the three views with a fourth view called All-View. The associations are identified by an offered ‘dictionary’ that describes concerns, context, and abstract information ([US Department of Defense \(2010\)](#)).

DoDAF is a broad, all-encompassing framework and conceptual model, which assists stakeholders to be effective in their decisions. DoDAF offers descriptions of resulting products in addition to support and instructions for consistency. DoDAF aims to be a ground to integrate cooperating architectures of systems with an ultimate goal of interoperability. DoDAF uses basic graphics, tables, and text to facilitate picturing and understanding the architectural concerns ([Urbaczewski and Mrdalj \(2006\)](#); [US Department of Defense \(2010\)](#)).

DoDAF aims to enable architecture development by offering an all-inclusive group of architecture concepts, methods, and best practices. The recent development of DoDAF has described the following set of viewpoints: Systems, Service, Data & Information, Operational, Standards, Capability, Project, and All Viewpoints. A description of a service, service-port, service-description, and service-performer are offered in a DoDAF generic

meta-model. This has encouraged specialists to use DoDAF for purposes of service-oriented architecture (SOA) as a style of software design ([Alwadain et al. \(2011\)](#); [Urbaczewski and Mrdalj \(2006\)](#)).

2.2.8 Federal Enterprise Architecture Framework (FEAF)

The US Chief Information Officers (CIO) Council introduced FEAF in 1990 ([Council \(1999\)](#)). FEAF was developed to be compatible with the Clinger-Cohen Act, 1996 ([Council \(1999\)](#)), which forced Federal Agency CIOs to build, support, and simplify the integration of architectures' description. FEAF offers five reference models: the Performance Reference Model, the Business Reference Model, the Service Component Reference Model, the Technical Reference Model, and the Data Reference Model. Each of them describes relevant terminology and architectural context of use. FEAF also offers useful documentation defining potential concerns and affected elements ([Council \(1999\)](#)).

FEAF was developed and implemented to integrate different architectures of various Federal Agencies in order to facilitate improved, fast, and cost-effective access to information. The dominant objective of FEAF is to enable and encourage communication of Federal information for the Federal Government. FEAF presents guidelines to develop architectural segments independently. This framework has a strength in that US Federal Agencies rely on FEAFs Practical Guide as their guidance for architectural frameworks. FEAF is flexible and isolated from the employed tools, final products, and methods ([Council \(1999\)](#)).

2.2.9 Model Driven Architecture

The following will offer a short introduction to the main constituents of Model Driven Architecture. First, we will introduce domain specific languages. This introduction outlines the key challenge of developing such a language in addition to a short depiction of a suitable way to develop it. Second, we will offer an overview of the concept of meta-modelling, supplemented by an illustration of common ways to utilize a meta-model. Third, we will present a holistic viewpoint on the subject of Model Driven Engineering.

Domain Specific Language (DSL)

A domain-specific language (DSL) is a language that is openly intended for a single target domain ([Spinellis \(2001\)](#)). The expressiveness of DSL is higher in respect to the domain's constructs that are tailored specifically in the language. Moreover, the abstraction of the

domain is proposed in the language. An example of DSL is the Structured Query Language (SQL). DSL will enable a more comprehensible expression of domain issues than general purpose languages. The availability of an enhanced expression will contribute to the problem-solving progression ([Spinellis \(2001\)](#)). DSL will be initiated with the intention of finding a means of effectively dealing with problems of a particular domain. In comparison to general purpose languages, DSL has a significant improvement in usability ([Thibault et al. \(1999\)](#)). The suitability of the dedicated notations in DSL increases the efficiency and the maintainability of the problem domain. The benefits of DSL can be measured by domain experts, which will enable them to develop the language.

The challenge of developing DSL is the acquiring of experts on language and domain in unison. Another factor that risks the whole development is the ability to justify the need for DSL. The executability of a DSL is not a compulsory characteristic ([Mernik et al. \(2003\)](#)). The broad nature of IT governance might affect the capability of its domain-specific language. This might cause the production of a domain-specific language that can be utilized in other domains; similar languages are called domain adaptive languages. This type of language is designed with a specific domain in mind, but has the capability of being utilized in other domains also.

The design and definition of DSL can be done through a number of approaches. Determining the appropriate means of defining a DSL will need considerable reflection. However, in our context, two of these approaches will be studied. First, the definition can be done with the construction of a meta-model based on a meta-language; initially, Meta Object Facility (MOF) is considered as the meta-language used. Second, the definition can be done with the specialization of a Unified Modelling Language (UML) meta-model by the means of UML profiles. A deep study of the two means can be found in [Weisemöller and Schürr \(2008a\)](#). [Weisemöller and Schürr \(2008a,b\)](#) have concluded that the first approach is stronger than the second, while the second is better supported with a tool-set. These two approaches are preferred because UML and MOF were initiated by the Object Management Group (OMG) and correspond to the principles of model driven engineering, which are introduced next.

Meta-Modelling

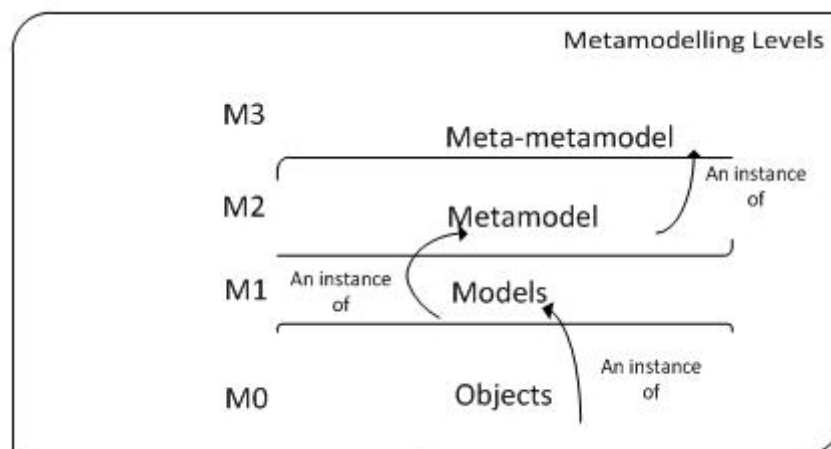
The complexity associated with modelling multifaceted systems is softened with the use of a meta-model. A meta-model is a model of the modelling language. It is a means of attaining the flexibility of the modelling language that needs to be sustained by various formalisms and modelling patterns. A meta-model offers the potential structures that would be represented in the modelling language. Moreover, if we apply the meta-modelling

concept to the meta-model itself, then the formalism of the meta-model can be modelled by a meta-meta-model, see Figure (2.7). The essential constituents required to form the meta-model's formalism is provided by the meta-meta-model.

An instance of the formalism is the UML class diagram, which is consistently utilized as a way of meta-modelling. However, the comprehensive specification of the formalism requires the facility of expressing constraints in meta-specifications. A common way to introduce constraints is the addition of a constraint language to the meta-formalism. Constraints are regularly represented textually due to the graphical nature of meta-modelling formalism. A widespread constraint language is the Object Constraint Language (OCL).

Unified Modelling Language (UML) was initiated by the Object Management Group (OMG) (Rumbaugh and Booch (1999)). UML uses a set of notations to graphically represent systems designs. UML is publicly approved as a standard to model object oriented designs. A detailed description of the language's semantics is provided. Within the language, there are a number of different diagrams to enable the representation of various features and aspects of the system design. The different diagrams are usually complemented with descriptions to provide an inclusive model.

FIGURE 2.7: Meta-modelling levels.



The UML class diagram is utilized frequently as a way of meta-modelling. Therefore, OMG has provided a way to adapt the modelling abilities of UML in order to fulfil the requirements of special application domains. This is done by an extension mechanism called UML profiles. This will allow extenders to benefit from the superiority of approved general concepts.

OMG also initiated the Meta Object Facility (MOF) as a standard to build meta-models. MOF provides the M3 meta-meta-model in the meta-modelling levels, see Figure (2.7). It can be used to construct the abstract syntax of DSLs. Some languages extended MOF to enable executable actions to supplement MOF models, such as Kermeta. This can construct the semantics of new DSLs. MOF itself is a DSL utilized to describe meta-models.

Model Driven Engineering

Model Driven Engineering (MDE) technologies were initiated to overcome the existing limitations associated with various platform technologies, as the languages' incapability of lessening the platforms' complexities and the languages' incapability of representing fully domain concepts. MDE supports developers with abstractions to develop systems in terms of design instead of the underlying platform. MDE technologies cover and unite two main concepts.

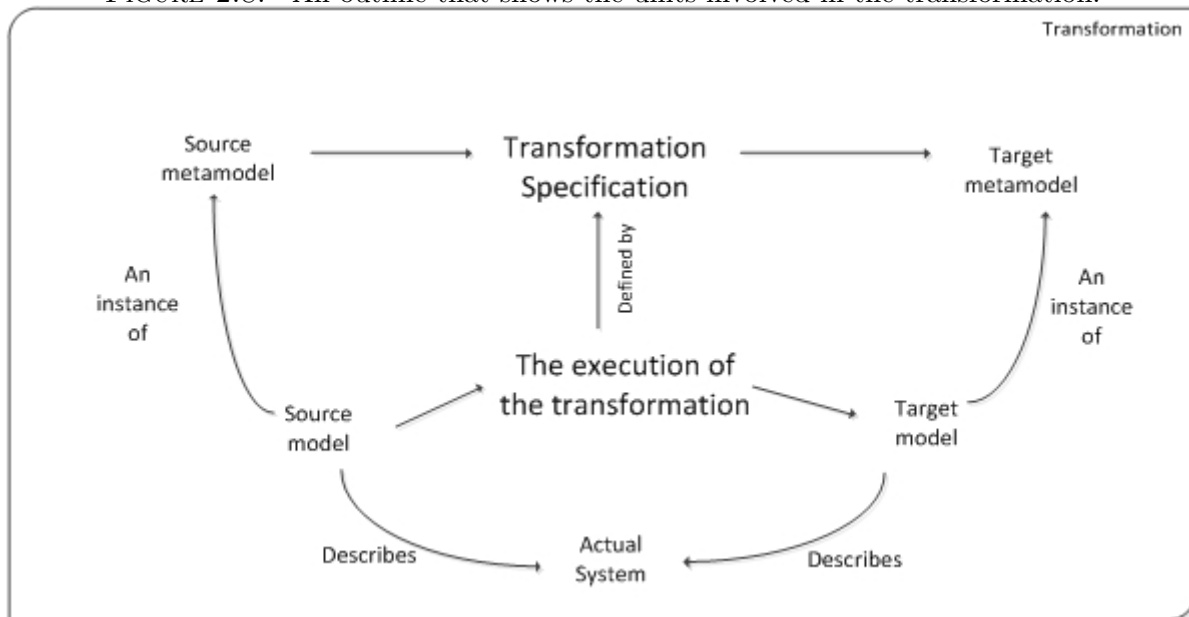
The first concept is domain-specific modelling languages (DSMLs) which are defined by means of meta-models. Meta-models provide the essential semantics and constraints of the domain concepts. The associations between these domain concepts are also represented by the meta-models. DSMLs formalize the specifications, actions, and the structure of the domain's applications. The elements constituted by the meta-models can be utilized to construct applications.

The second concept is transformation. Kleppe et al. have defined a transformation as *'an automatic generation of a target model from a source model, according to a transformation definition'* (Kleppe et al. (2003)). This concept enables deep model analysis and afterwards the combination of different sorts of model representations or codes in some cases. The consistency between models analysis information and application implementation is provided by different artefacts synthesis. Automatic transformations, between separate models at different levels of abstractions, offer a major method of development, see Figure (2.8).

MDE is a gradual progressing approach over earlier approaches of language abstractions and high-level platforms. Meta-modelling of DSML can correctly correspond to domain concepts. DSML assists domain experts in ensuring that stakeholders' requirements are met, by representing graphically well-known domain notions. Another major advantage of MDE is the early identification and avoidance of errors, by constraint and model checking carried out by the MDE toolset.

Models are the key valuables of MDE, while model transformations are the core of MDE. A model can be described as a connected set of prescribed constituents defining something constructed for a principle that is adaptable for a specific type of analysis. *‘Model-driven development is simply the notion that we can construct a model of a system that we can then transform into the real thing’* (Mellor et al. (2003)). MDE allows models to be selected before possibly being extended and then constructed from a number of interconnected models, rather than reconstructing systems from scratch each time the technology changes.

FIGURE 2.8: An outline that shows the units involved in the transformation.



2.2.10 Treasury Enterprise Architecture Framework (TEAF)

The Department of the Treasury introduced TEAF in 2000 (Systems and Software Consortium (2005)). The motivation behind TEAF is to map and manage associations between architectures of different treasury offices based on strategic planning. This was important for managing IT resources across different offices. The goals of TEAF include enabling integration, communication, and improvement of shared concerns. TEAF comprises the definition of work products for representing architecture descriptions. TEAF clearly asserts that these work products must support FEAF models and DoDAF products. TEAF described a matrix guiding the employment of the framework.

The TEAF matrix offers a basic view of the enterprise architecture from different perspectives. The TEAF matrix consists of 16 cells comprising the work products describing the relevant information for identified concerns (Systems and Software Consortium (2005)).

TEAF documents the specification of each cell that incorporates the context of use, candidate modelling tools, and shared perspectives. TEAF does not offer a detailed meta-model for the specification of the cells but documents some high level description. TEAF describes roles, connected responsibilities, and team structure of stakeholders involved in the development process. TEAF has a limitation in terms of lacking techniques for developing a specification of the documents ([Systems and Software Consortium \(2005\)](#)).

TEAF specifies the development process with four basic activities: defining an EA strategy, defining an EAM process, defining an EA approach, and building an EA repository. They act as a roadmap describing a procedure model for the whole development in addition to gradually reflecting on the consecutive rows of the TEAF matrix ([Systems and Software Consortium \(2005\)](#)).

2.2.11 Kruchten's 4+1 View Model of Architecture

Philippe Kruchten established his 4+1 view model of architecture in 1995 ([Kruchten \(1995\)](#)). Kruchten's view model is also thought of as a key model for architectural description. It has to be considered that Kruchten's view model mainly discusses issues of object oriented design. It defines five synchronized views. One view is overarching and named the scenarios view. It illustrates the way the structures of the other four views collaborate. The scenarios view is presented as instances of use cases. In addition, the scenarios view helps in designing the architecture by facilitating the search of architectural structures ([Kruchten \(1995\)](#)).

The other four important views are: logical, process, development, and physical views. The logical view uses class diagrams and state-transition diagrams to present the design's object model. It illustrates the services that the system would deliver to its clients. The process view is utilized to show and assess message flow and process loads. The development view uses module and subsystem diagrams to present export/import associations in order to depict the software's static organization. The physical view addresses the complexity of physical blueprints by describing the mapping of the software onto the hardware. Kruchten's view model agrees and allows some views not to be used for every architectural description. Structures of different views can be associated, as different views are not isolated from each other ([Kruchten \(1995\)](#)).

2.3 Discussion Points on Why TOGAF is a Sound Basis for Our Solution

There are a number of strong discussion points that signify the credibility of TOGAF to be selected as a basis for our solution. This section presents these points.

TOGAF is considered an industry EAM framework with an important impact of ADM processes in any planned customization or adoption of future solutions ([Tang et al. \(2004\)](#); [Urbaczewski and Mrdalj \(2006\)](#)).

TOGAF enables the adaptation of extension blocks with no need for major rework. This is due to its satisfactory scope of applicability and conceptual context ([GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [McGovern \(2003\)](#); [Weisemöller and Schürr \(2008a\)](#)).

The specification of the conceptual assumptions of TOGAF encourages commercial products and researchers to develop proposals that are compatible with the offered specification. This is due to the extensive supporting documentation and ongoing development of its underlying language ([Tang et al. \(2010\)](#); [The Open Group \(2009b\)](#)).

A costly process in any development of EA is ensuring the consistency and compatibility of terminology. TOGAF is a widely used framework and being compatible with its terminology will speed the impact examination process ([Tang et al. \(2004\)](#)).

The Architecture Continuum in TOGAF defined a number of rules that ease any potential reuse of new notions influencing the construction of views. This is helpful in small changes of already existing views in TOGAF ([The Open Group \(2009b\)](#)).

The lack of explicit expression of stakeholders' constructs and concerns might be considered a limitation of TOGAF. However, we consider this a potential opportunity in describing our view of these concerns from scratch ([Urbaczewski and Mrdalj \(2006\)](#)).

TOGAF employs a range of descriptions from the Foundation Architecture in order to enable producing an enterprise-specific architecture. The existence of these various descriptions encourages our aim to produce a distinct set of context-requirements for the work products in order to enhance understandability (McGovern (2003)).

A number of studies have shown that TOGAF is strong on the Business Architecture aspects (GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert (2005); Tang et al. (2004)). The studies also state that TOGAF does not offer details on planning and maintenance aspects. This a major support for the efforts planned for our research as TOGAF has only basic provision.

TOGAF is inclusive in terms of the offered actual processes. TOGAF documents the rules for decision-making, IT resources, and architecture principles. This helps presenting TOGAF for open systems development (The Open Group (2009b); Weisemöller and Schürr (2008a)).

A major factor in any new development is its potential applicability and usability. As our solution is an extension to an existing framework, this is affected largely by the popularity of the chosen framework. A number of studies have shown the prominence of TOGAF in EA efforts around the world and it is the most frequently used framework (Tang et al. (2010, 2004); Urbaczewski and Mrdalj (2006)).

A number of studies have indicated that there is a distinction between EAM frameworks in terms of their compliance with industry or government standards. They stated that TOGAF is largely accepted as the EA industry standard (Tang et al. (2010)). Therefore, TOGAF is ideal, as our research has focused on enterprises in the industry sector.

Many enterprises opt to use a customized or hybrid EAM framework approach. ADM of TOGAF is the most adapted element in customized approaches (Urbaczewski and Mrdalj (2006)). Another very popular element is the Information Base of TOGAF. This also encourages researchers to develop their proposals consistent with TOGAF components as it addresses more attributes to a wider extent. In summary, TOGAF is frequently used for its ADM, Information Base, vendor-neutrality, compliance with industry standards, and

the interoperability of its components employment ([Cameron and McMillan \(2013\)](#); [Urbaczewski and Mrdalj \(2006\)](#)).

We build our proposal on top of TOGAF. One of the most important motives is the fact that our action case study takes place in an enterprise employing TOGAF. Action research is driven by the environment where the research will be conducted ([Fals Borda et al. \(1991\)](#)), see Chapter (3).

The meta-model of TOGAF recognizes a number of constituents that offer a strong basis for our extended meta-model, see Chapter (6). Examples of these constituents are: actor/-contract in the business layer, measuring elements of business service, information system service, platform service, quality of service, and service policy ([GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#)).

EAM frameworks manage the different forms of alignment in a distinctive manner. Any lack of architectural alignment can be credited to the underlying models of the examined frameworks. **In the following, a discussion of different alignment forms and EAM frameworks' viewpoints is presented.**

The first form of alignment requires the existence of explicit guidance about architectural alignment concerning changing goals of external stakeholders, and their implications on information systems. One of the key differences is how information resources are represented, either as part of or independent of the enterprise. The following paragraph provides an analysis of different EAM frameworks' perspectives on this form of alignment.

TOGAF provides unsatisfactory description concerning the term 'enterprise benefits' ([Aier et al. \(2011\)](#); [Cameron and McMillan \(2013\)](#)). Zachman offers unsatisfactory guidance concerning the association between information systems and goals of planner and owner ([Lankhorst \(2009\)](#)). EAMPC, TEAF, and DoDAF plus other frameworks manage the alignment on the basis of technology requirements rather than goals of business ([Magoulas et al. \(2012\)](#)). Other frameworks including Kruchten's 4+1 View Model encourage agreement of shared requirements of the all-inclusive architectural descriptions, nonetheless providing insufficient practical guidance ([Wegmann \(2002\)](#)).

The second form of alignment requires the existence of explicit guidance about architectural alignment concerning changing requirements of business units of the enterprise, and their implications for information systems. One of the key differences is how they represent processes and activities. They differ in clarifying the relationships between components of EA and processes/activities. This is related to how the enterprise as a whole is represented within its environment. TOGAF provides adequate alignment between internal and external stakeholders by the use of operational contracts ([Koning et al. \(2006\)](#)). The following paragraph provides an analysis of different frameworks' perspectives on this form of alignment.

TOGAF provides unsatisfactory guidance concerning the integration and implementation between services and business processes ([Henderson and Venkatraman \(1999\)](#); [Maes \(2000\)](#)). Zachman offers unsatisfactory guidance concerning the association between information systems and business processes ([Maes \(2000\)](#)). EAMPC presents a pattern ensuring the synchronization between information systems and delivered services; but does not offer practical guidance concerning the modelling of the functional activities. Kruchten's 4+1 View Model provides sound alignment among business processes and principles of functional activities ([Plazaola et al. \(2008\)](#)).

The third form of alignment requires the existence of explicit guidance about architectural alignment concerning specification of responsibilities, and their implications on information systems. One of the key differences is how the underlying model supports responsibilities. This differs in representing responsibilities in an independent component rather than in an association between EA components. TOGAF provides adequate alignment between responsibilities and structural entities by the use of governance contracts ([Wegmann \(2002\)](#)). The following paragraph provides an analysis of different frameworks' perspectives on this form of alignment.

TOGAF provides unsatisfactory guidance concerning the association between the changing area of responsibilities and business goals ([Koning et al. \(2006\)](#)). Zachman lacks guidance concerning the changing area of responsibilities ([Wegmann \(2002\)](#)). Some frameworks, such as TEAF, provide guidance only to selected high-level stakeholders. EAMPC presents a pattern ensuring the representing of responsibilities in functional areas, but does not offer satisfactory guidance concerning the modelling of the operational activities ([Maes \(2000\)](#)).

The fourth form of alignment requires the existence of explicit guidance about architectural alignment concerning constant and clear availability of informational needs, and their implications on human stakeholders. One of the key differences is whether they consider

cognitive distance and industrial proficiencies or not ([Magoulas et al. \(2012\)](#)). The following paragraph provides an analysis of different frameworks' perspectives on this form of alignment.

TOGAF endorses specification for communication and availability of information, but provides unsatisfactory guidance concerning prevention of information inconsistency. Some frameworks document the need for collective understanding via interaction between internal and external stakeholders. Zachman offers unsatisfactory guidance concerning how information requisites should be represented, such as comparability ([Maes \(2000\)](#)). EAMPC offers unsatisfactory guidance concerning the alignment of stakeholders, their capabilities, and mental models to EA ([Koning et al. \(2006\)](#)).

The fifth form of alignment requires the existence of explicit guidance about contextual alignment concerning the adaptation to changes in the external environment of the enterprise and its implications to the internal components. This is a very important form of alignment to our research problem, because current endeavours focus mainly on guidance concerning internal units of the enterprise. This is very crucial due to the need for an enterprise to instantly adapt to its environment. Therefore, contextual alignment is key regarding changes in new economic, legal, and political regulations that affect an enterprise. The following two paragraphs provide an analysis of different frameworks' perspectives on this form of alignment.

TOGAF provides adequate alignment between governance and structural entities by the use of governance and operational contracts, in addition to demanding conformance with new regulations ([Wegmann \(2002\)](#)). TOGAF provides unsatisfactory guidance concerning the association between changing IT strategy, enterprise mission, and EA ([Koning et al. \(2006\)](#)). Zachman offers unsatisfactory guidance concerning contextual alignment, and how to distinguish physical assets from system rules ([Maes \(2000\)](#)).

EAMPC presents a pattern ensuring the contextual alignment between heterogeneous environments of an enterprise by merging functional blocks, but it does not offer practical guidance concerning the adaptation of the enterprise to constant changes ([Koning et al. \(2006\)](#)). Some frameworks provide viewpoints for external entities that might affect the enterprise, but they lack supporting guidance on the practical implementation on harmonizing expectation of internal and external stakeholders.

In summary, the lack of alignment will eliminate any coherence of EA. All frameworks offer a set of terms, rules, and guidelines in order to enable designing, building, and assessing an EAM capable of supporting alignment between its components. No single EAM framework has offered clear and sufficient guidance to all requirements of alignments forms. Some frameworks offer better support than others, as discussed in the previous paragraphs.

2.4 Introduction to the Research Area

In this section, we describe the research area in detail (subsection (2.4.1)), supplemented by the EAM frameworks' viewpoint on the evolution of EAM in relation to change, see Table (2.4). In addition, this section presents the existing nature of EAM frameworks and how that nature motivates the research objective, see subsection (2.4.2). Furthermore, we highlight three approaches with related research points, which motivate our research, see subsection (2.4.3).

In short, this research will present a practical methodology to address the lack of EAM frameworks' capacity to cope with dynamism. This supports the foundation of most EAM frameworks with a methodology that harmonizes with their practice. The solution will offer a systematic way to deal with a specific weakness in EAM frameworks, which will eventually contribute to their capacity to cope with dynamism. We will address this weakness by representing the underlying business behaviour. Our design through the use of action research principles has driven our research after a number of recursive investigations.

In enterprises of considerable size the lack of correspondence between business and IT is typically bridged by means of planning and sustaining what is commonly known as enterprise architecture (EA). In short, EA is a high-level demonstration and interpretation of the enterprise, utilized for maintaining the association between business and IT.

EAM frameworks are usually employed in larger enterprises in order to manage IT projects and their cost. This is derived from their overriding need to meet their business objectives. Assumptions made in EAM include enhancing the flexibility of the enterprise as well as justifying the role of IT to business targets (Buckl et al. (2009b); Luftman et al. (1993); Wagter et al. (2005)). This necessitates traceability of business objectives to EA. Traceability enables the fast identification of effects on EA of any change in business objectives and vice versa. Therefore, it has been asserted that managing change effectively is the best way to achieve this traceability (Boh and Yellin (2007); Buckl et al. (2009b, 2011c); Ross

et al. (2006)), whether change has occurred in EA or in business goals.

The previous abstract description of the research problem will raise a number of issues. First, the capability of existing EAM frameworks has to be examined in relation to achieving relative business goals. Second, there is a need to examine whether business goals and behaviour, of both business and EA itself, are explicitly represented. Third, the capacity of EAM frameworks to realize this bidirectional traceability should be assessed among business goals, business-behaviour, and the constituents of EA. If this realization is not satisfied, then we need to examine what EAM frameworks need in order to realize traceability and how constant changes in EA or business goals affect this fulfilment, i.e. business behaviour dynamics.

2.4.1 Research Area

Large organizations typically have multiple information systems, created at different times for different purposes and serving different users and functions. These various systems may have many types and numbers of interrelationships. Managing and sustaining such complex systems is often problematic, and indeed may be a leading cause of failure of today's enterprises. EAM frameworks are conceptual models of the interconnected systems deployed in a given organization, the interrelationships of these various information technology (IT) systems, and the relationships between these IT systems and the business functions and operations of the enterprise.

Most EAM frameworks are static, and do not readily cope with the dynamism of modern enterprises. This research project explores ways to create elements of EAM frameworks able to cope with dynamic environments. The proposals will be developed and assessed through means of a detailed case study within a semi-governmental enterprise.

The field of EAM is evolving and appealing, with growing attention from academia and industries (Lankhorst (2009); Ross et al. (2006)). Currently, a constantly dynamic environment of open economics, new policies, and advancing tools force enterprises to employ EAM functions (Buckl et al. (2011d); Lankhorst (2009)). Thus, enterprises aim to gain strengths reached through EAM functions.

The main intended advantages from utilizing an EAM function as stated explicitly by Weiss et al. (2013) are first, reliable planning of strategic-IT; the second benefit is to improve the alliance between business and technology; the third benefit is to optimize business

processes; and the fourth benefit is to have architectural guidance for initiatives ([Lagerstrom et al. \(2011\)](#)). Various indications highlight how significant is the field in practice, including the mass of contributions from academia and industries as well as naming EAM success as a top concern for high-level management by a number of consultancy firms ([Burton and Allega \(2010\)](#); [Lagerstrom et al. \(2011\)](#)).

This growing interest in EAM led to a variety of contributions and trends offering diverse proposals for methodologies, approaches, and guidelines. These proposals vary in terms of the used expressions and intended concerns. However, these proposals are consistent with a primary core of EAM, involving almost identical modelling language/meta-model and a method/function driving the conceptual model ([Ahlemann et al. \(2012\)](#); [Weiss et al. \(2013\)](#)). This is mainly due to enterprises customizing their EAM framework based on a standard one rather than employing all aspects of the selected framework, such as The Open Group Architecture Framework (TOGAF) ([The Open Group \(2009b\)](#)).

Influential attention paid to architecture for industrial products, throughout the industrial era, has enabled the creation and development of these products. The same high level of attention must now be paid to architecture for enterprises, throughout this information era. This is a necessity because enterprises are changing rapidly and escalating in complexity. Existing complex organizations face challenges reacting to different kinds of change. One of the main causes is the lack of awareness about the complicated structure of certain entities inside the enterprise. This knowledge is usually preserved in the minds of individuals or departments responsible for the direct processing of this knowledge. Loche has stated *‘Enterprise Architecture (EA) is the process used by a business to make explicit representations of enterprise operations and resources, rather than relying on implicit notions or understanding in individual managers’ heads’* ([Loche \(2003\)](#)).

Several factors draw attention to the key role EA plays in modern enterprises. These factors include increasing legal regulations, customized client requirements, and shorter time to market. An example of the regulations is the USA’s Sarbanes Oxley Act that obliges enterprises to plan and document their financial architecture ([US Congress \(2002\)](#)). Enterprise architecture can be utilized as a means of achieving strategic objectives of an enterprise. One of these objectives is to adapt and respond to a frequently changing environment. Another objective is the representational association between business concerns and activities on one side and information systems on the other side. The availability of a holistic view of the enterprise is also an objective that can be realized from EA.

The significance of utilizing EA is observable due to the clear understanding of resources and agents engaging with the enterprise. In addition, the clear representation of an enterprise enables the enterprise to acknowledge its needs and development priorities. The key concern for an enterprise is not to foresee the future but to enable the achievement of that future, which is facilitated through the use of EA. Furthermore, the clear understanding of all formerly implicit information is a huge advantage to know accurately an enterprise's capabilities and the processes' complexity.

One more benefit of EA is the potential to align business goals and processes with technological infrastructure. EAM builds an architectural representation of the existing state of the enterprise, accompanied by the planned state of approved projects and the future state of intended objectives. This feature facilitates a managed evolution of the enterprise. Enterprise architecture eases internal and external communication about the key elements and functioning of an enterprise.

The area of research for this study is the creation of EAM frameworks for dynamic organizations. We offer organizations the means to enhance their ability to achieve their objectives and to manage change.

In the current business environment and surroundings, organizations have to constantly change, advance, and familiarize themselves so as to reform the basis of their business practices (Ross et al. (2006)). This is due to the difficult changing financial state, regulations, and technological developments. This demand for constant change affects directly the state of what organizations call enterprise architecture (Lankhorst (2009); Ross et al. (2006); Spewak and Hill (1993)).

Organizations describe EA as the primary structure of the organization expressed in its components, with clear illustration of the associations between these components, as well as the environment, complemented with the rules managing its design and ongoing development (Jonkers et al. (2004); Lankhorst (2009); McGovern (2003)). The area of EA is highlighted, by many authors, as one of the most affected by change (IEEE and ISO/IEC (2007)). Wagter et al. (2005) have stated that the planning aspects of EA should be able to positively recognize and aim for prospective improvement with the quality of responding to constant change.

- The area of EAM can be motivated and led by the earlier needs, with concentration on the planning aspects of EA. A comprehensive and all-inclusive view of structural change is supposed to be offered by EAM, which will assist organizational revolution.

Thus, EAM will be looking to sustain and develop the alliance between distinct parts of the organization. Figure (2.9) sketches all the related components to our research problem. EAM will largely be concerned with supporting the shared alliance between IT and business (Jonkers et al. (2004); Lankhorst (2009); Luftman et al. (1993); Ross et al. (2006); Spewak and Hill (1993)). This is considered to be a main aim of any organizational restructuring and consequently for EA planning (Jonkers et al. (2004); Luftman et al. (1993); McGovern (2003)). Lately, the planning aspects of the architecture in EAM have been acknowledged with specific consideration in accordance with the continuing awareness about EAM, see Table (2.4).

FIGURE 2.9: Related components to the research area.

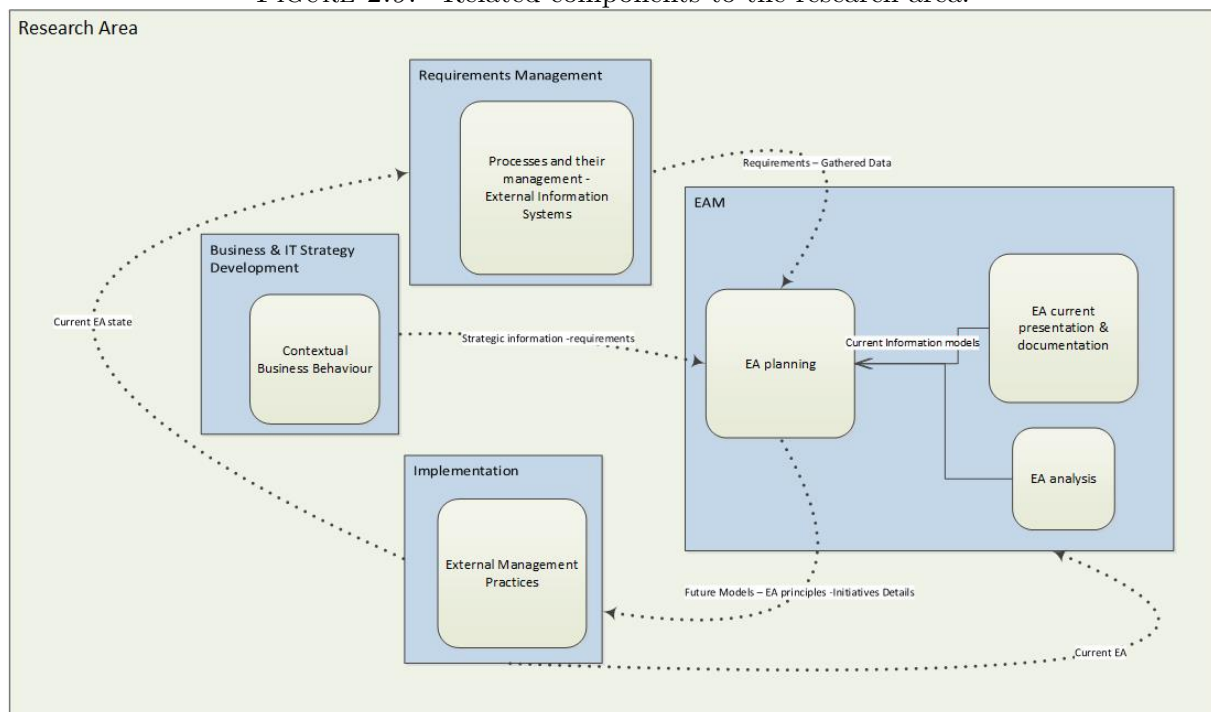


TABLE 2.4: Overview of different EAM frameworks' viewpoint on change

Zachman	Its classification technique can be utilized to locate areas where potential change can occur, in terms of understandable decomposition of knowledge. It can be supported by a description of guidelines and recommendations; however, a practical process will not be added, since it does not offer real-time methods to manage EA. Zachman has encouraged designers, supervising the whole process, to detect any such changes or weaknesses between different models and even rebuild some models to maintain consistency. Zachman has predicted that frequent change demands will impose a need for a structured expressive representation.
EAMPC	Changes will initially be approached by the introduction of new patterns aiming to address dynamic changes. It will be expected to need some kind of collaboration with existing patterns, which consequently will require an New viewpoint patterns will be introduced to offer a deliverable that absorbs a series of updated EA results matching different update stages for the same concern. EAMPC can utilize proven practices to address certain change demands as a set of methodologies that have time after time shown outcomes better than any other methods trying to address the same concerns
TOGAF	Development of a process guiding the update/transformation process will be predicted. Alignment with the ADM process of TOGAF will be a key challenge for this development. New information models are expected to be introduced. The architecture change management stage of the ADM cycle will be mainly affected by the proposed solution. Since it is concerned with the constant observation of changes in the latest technology, performance targets and business matters that might initiate further developments. This stage will be responsible for ending a cycle and arranging the launch of a new iteration. The opportunities and solutions stage need to consider dynamic change requirements for future updates.

- The complicated issue of defining and guiding change in enterprise architecture has been distinctively highlighted by a number of researchers. Their aim has been to achieve this in a manner that is feasible for organizations during transformation. An overview of how different EAM frameworks have viewed change can be seen in Table (2.4). Several contributions can be found in [Aier and Gleichauf \(2010a\)](#) and [Aier and Gleichauf \(2010b\)](#); [Buckl et al. \(2009b\)](#), where they and others offer solutions

to different issues in the planning of EA. Each one mainly emphasizes one particular side of transformation planning.

2.4.2 Existing Nature of EAM frameworks that Support the Research Objective

The fundamentals of EAM have demonstrated the demand for a framework that adheres to a number of principles and requirements that support the problem presented in this research. A principle in designing enterprise architecture is to design with the awareness that there are many unknowns, such as new technologies and environmental issues. If we are able to achieve this sophistication of planning, then we should enable the enterprise to accommodate change. Another key principle is the continuous consideration of the enterprise's broader context, such as external environmental factors.

EAM will not attempt to foresee the future but to provide the capability to adapt to any potential changes, because it is impossible to take into account all potential upcoming changes. Schekkerman has urged EAM to be derived from an enterprise's strategic vision, stating that '*this vision bridges the extant status of the firm **where it is?** and its projected future status **where it wants to be?***' (Schekkerman (2006)).

The research area was partially derived from the principles highlighted in the previous paragraph. However, a different description of EA and its scope has offered some form of the qualities that could be extended and utilized for the purpose of this research. These qualities revolve around the feature of EA planning. The next paragraph will present a noticeable quality of EA planning that offers a good ground for development.

The EA planning description has suggested the need to document two distinct architecture descriptions of the same enterprise. One is called *As-Is* enterprise architecture and the other is called *To-Be* enterprise architecture.

BASELINE *current* enterprise architecture should depict the current state of the enterprise using several means. It is also called *As-Is* enterprise architecture. The state encloses the technological infrastructure and the existing business activities.

TARGET *future* enterprise architecture should depict the upcoming state of the enterprise. It is also called *To-Be* enterprise architecture. The state is derived from enterprise objectives and plans for business and technology. It shows the effects on the enterprise infrastructure and business practices.

The TRANSFORMATION PLAN should describe the utilized practice to transform the current EA to the target EA. An example is different scheduled activities, which can be simultaneous or interreliant. In addition, it illustrates gradual stages of the process. It is also called a sequencing plan. The transformation plan takes a document form.

The potential way to utilize this is either by developing a process to guide, develop, and manage the transformation plan practically, or by explicitly identifying a further description of required number and kinds of architecture depictions supported by a clear plan to move from one to the other.

The presented solution should be aligned with the existing nature of EAM employment. The solution should have a number of key features to ensure its practicality and coherence.

The realization of the previously mentioned features requires an EAM framework ensuring the following qualities. These qualities are discussed in more detail in Chapter (5); we will state them again next for their importance to the development. An EAM framework should not be purely inwardly centred. It has to cover all sides of the extended enterprise, in order to consider stakeholders, standardization and governmental and business bodies that have an influence on the enterprise. In short, an enterprise architecture should be holistic in scope.

Another important quality of enterprise architecture is to be established collaboratively. This means that representatives from all stakeholders, with different perspectives, should participate in building the EA. The represented alignment between business and IT should be understandable and visible to all stakeholders. In addition, EA should be a way to show the business value from applying the proposed solutions.

Analytical methods should be offered by EAM frameworks to maintain the evolution of EA over time. Suggested solutions must be accompanied by the means to evaluate, test, and reflect them to the facts on the ground. However, an argument can be made that this feature might increase the complexity of EAM and exceed its domain. EAM frameworks should not make any assumptions about the use of a specific implementation approach ([Schekkerman \(2006\)](#)).

The following explains what were our assumptions of what we considered important constituents of any extended EAM meta-model. This was at an early stage of the development, and was based only on literature, and before the start of our action case study.

- The way architects are utilizing the **stakeholder** concept. Are they utilizing it as intended, by demonstrating the existence of an entity that contributes to the progress of the enterprise? Clearly, this concept is well recognized in business, in addition to having a comprehensively defined meaning offered here for its proper utilization.
- The way architects are utilizing the **goal** concept. Are they utilizing it as intended, mainly the difference between soft and hard goals? Because even those goals are abstractly understood in businesses, architects could ignore the distinction between different goals. This might be due to their view that the distinction between soft and hard goals is irrelevant to the design of their models.
- The way architects are utilizing the **decomposition** relation. Are they utilizing it as intended, by using the decomposition relation to break up a goal into clearer sub-goals, signifying that the realization of the combination of all sub-goals entails the realization of their top goal? For instance, a top goal to cut costs will be refined into sub-goals to cut the costs of interior services, to cut the costs of exterior services as well as cutting the cost of technology applications.
- The way architects are utilizing the **contribution** relation. Are they utilizing it as intended, to explicitly signify that the attainment of a specific goal will affect the realization of an additional goal? For instance, a goal to enhance service delivery automation affects positively the goal of cutting services costs.
- The way architects are utilizing the **means–end** relation. Are they utilizing it as intended? We have controlled its use in our proposed solution to be an affect from a requirement to a goal.
- The way architects are utilizing the **conflict** relation. Are they utilizing it as intended? We adapt its use to designate goals that cannot at all times all be fulfilled simultaneously. It will be expected that architects will not initially be using conflict relation. The viewpoint of the architects should be documented and analysed. An explanation should be offered to highlight the difference between a conflict relation and a negative contribution.
- It must be explained that the best way to represent a **requirement** is as a **goal** that should be accomplished by one component in EA. Current EA designs show that requirements might not be represented in a consistent way by architects. An instance of a requirement causing such inconsistency is ‘The employment of marketing practices has to be enhanced’. It must be clear to architects that such examples are business goals, and they should not be represented as a system requirement.

- The way architects are utilizing the **concern** concept. Are they utilizing it as intended, to be utilized for what is a stakeholder's concern, for instance sales, cost, or revenue? We should observe, record, and clarify any misunderstanding of the contrast between concerns and goals. Inconsistent use of concerns might occur to signify firm statements that seem to be objectives rather than concerns, for example an objective to reach a working environment that is outcome-oriented.
- The distinction between goals, concerns, requirements, and **assessment** must be clear. Different EAM frameworks partially cause some confusion. The proper use of annotation will be key to the success of the treatment.

2.4.3 Related Work in Parallel Approaches

This subsection offers a view on earlier proposals that show an insight into the significance of our research problem. In addition, it describes their attempts to enhance related research issues.

The development of an EAM function adaptable to a dynamic environment is a complex mission ([Ahlemann et al. \(2012\)](#); [Hauder et al. \(2012\)](#); [Maynard and Gilson \(2014\)](#); [Weiss et al. \(2013\)](#)). A few attempts in the literature have addressed partial aspects of the same goal, specifically the following:

- The first approach claims that the proper way for enterprises to manage their EA is to integrate parts of diverse EAM frameworks into a customised EAM function particularly for the employing enterprise. This approach offers a number of extensions for Enterprise Architecture Modelling Language (EAML). It gives enterprises the option to choose related and applicable extensions and integrate them. The integration should consider the consistency of terminology. See the approach in [Ernst \(2010\)](#). This approach aims to enable enterprises to be responsive to changes by its ability to select practices proven within different EAM frameworks to deal with particular problems.

A number of drawbacks emerge from the nature of such integration. The most apparent drawback emerges from the confusion over inconsistent terminology. In addition, the resultant representation of EA from practices offered in different EAM frameworks affects the actuality of EA models; particularly in relation to perception and transformation linked to different stakeholders. Another drawback is the suggested pattern of models, where the viewpoint-model might be in contradiction with the

source of information and EA model. To overcome this, it is suggested that jointly all viewpoint-models must reflect all elements of EA models. A major drawback is the lack of guidelines driving the integration into a framework matching the needs of a particular enterprise.

- The second approach claims that the proper way for enterprises to manage their EA is to have their own framework. It hands freedom to enterprises to build, shape and identify their EAM function/practices from the top. See approach in [Buckl et al. \(2007\)](#). It aims to enable enterprises to flexibly address the particular concerns of the enterprise by the hands of experts working in the enterprise and principally aware of its concerns and business behaviour. This approach aims to enable enterprises to be responsive to changes by its flexible nature of design.

A drawback is the reliance on existing experts within an employing enterprise who are familiar with EAM. Another drawback is the costs implied by the offered flexibility, a number of these costs are stated in the approaches' publications. A major drawback is the resulting huge models with unlimited numbers of new terminology with no reflection to their impact on EAM practices, as they are just a result of the demands by different stakeholders. The gathering of unnecessary data exceeds the relevant target concerns. An important drawback is the lack of methods driving data maintenance, as the pattern of models are not sufficient of their own to manage collecting, representing and planning future EA.

- The third approach claims that the proper way for enterprises to manage their EA is to depend on a federated maintenance of EA models. See approach in [Fischer et al. \(2007\)](#). This approach focuses on the adaptation of current EA models to guide management practices. It claims that the success of a federated approach is dependent on the perception of different stakeholders. This approach constrains the utilisation to one EAM framework and then tailors it to counter identified source of changes. It also encourages the internal adaptation of EAML supporting the selected EAM framework.

This approach has a number of drawbacks. An apparent drawback from the adaptation is the conflict of keeping selected EAM framework concepts or adding new ones communicated within the enterprise. Another drawback is the potential lack of stakeholders' backing in conflict with utilising the selected EAM framework method. In addition, the suggested federated model maintenance might vary in terms of use vs. representation. Furthermore, as in the previous two, the lack of guidance and thorough elicitation of backbone requirements is another drawback. The guidelines

for employing the proposals have a noticeable impact on the applicable utilisation. For instance, how to deal with omitted concepts from the selected EAML.

However, these previous approaches share a weakness that they complicate the implementation of an EAM function and raise its cost, which conflicts with principles of EAM ([Ahlemann et al. \(2012\)](#)). In addition, the applicability of such approaches is undermined by the complexity of building a customised EA modelling language, which is difficult to be endorsed in reality.

As each one of the existing approaches has considerable benefits, nevertheless drawbacks from these approaches motivates the goal of our research:

- Their simplicity and usability is a major concern. The ability to offer a method that can be employed with minimum extension while realising considerable benefits is a motive of this research.
- Their interest in information is broad. The ability to drive information gathering is vital; in both restricted gathering of distinct information and automated gathering.
- Their open and inclusive practice is problematic. The ability to propose a method is confined to a precise set of goals. An instance is avoiding practices having satisfactory fulfilment in current EAM frameworks. Another instance is excluding techniques gathering unnecessary data.
- Their low consideration of specific practices to deal with changes within data maintenance practices in an EAM function. The ability to improve the level of responsiveness of data maintenance is significant ([Ahlemann et al. \(2012\)](#); [Hauder et al. \(2012\)](#)).
- Their proposals include a large set of new terminology. The ability to propose a method supported by an extension to the underlying EA language utilising an existing set of terminology with a small set of additions.
- Their common lack of guidelines to adopt small proposals. The ability to offer guidelines for employing the proposals plays a noticeable impact on the applicable utilisation. In addition, this will not be comprehensive unless it starts with a comprehensive elicitation of base requirements ([Ahlemann et al. \(2012\)](#); [Goethals \(2005\)](#); [Hauder et al. \(2012\)](#); [Ross et al. \(2006\)](#)).

There are some related attempts in other subjects. The Business Rules Group ([Business Rules Group](#)) has offered the Business Motivation Model (BMM) ([Business Rules Group](#))

as a model which links strategic objectives and elements in the architecture. BMM is currently an Object Management Group (OMG) standard. TOGAF presented efforts in ADM that attempt to associate EA and business goals ([The Open Group \(2009b\)](#)). On a corresponding path, there was a proposal for an extension of software architecture modelling with goal-oriented requirements engineering (GORE) techniques ([Van Lamsweerde \(2001\)](#)). However, notational considerations of GORE were ignored, while essentials of bulleted listing of objectives and stakeholders are the core of the extension.

[Stirna et al. \(2007\)](#) have illustrated an approach to EA modelling to facilitate linking objectives to models of the architecture. However, concrete activities were not presented. Goal-oriented language was proposed to relate objectives to a few elements of the enterprise structure by [Jureta and Faulkner \(2005\)](#). While EA models were not part of the study. Horkhoff and Yu has proposed a method to assess the accomplishing of objectives by enterprise models, which is illustrated in i^* ([Carvallo and Franch \(2009\)](#)).

For this development it must be considered that a key difficulty of utilizing GORE in reality is the complication of its notation. It has resulted in [Matulevičius and Heymans \(2007\)](#) that i^* ([Carvallo and Franch \(2009\)](#)) and KAOS ([Dardenne et al. \(1993\)](#)) include elements not utilized in reality as well as including different elements signifying equivalent constructs. Following an ontological investigation, they concluded in [Matulevičius et al. \(2007\)](#) that the i^* goal and soft goal are basically referring to the same thing, whilst the means-end and contribution relations are also equivalent ([Matulevičius et al. \(2007\)](#)). Furthermore, [Moody \(2009\)](#) and [Moody et al. \(2009\)](#) recognized several prospects for explanation and breakdown of the i^* notation. [Carvallo and Franch \(2009\)](#) claimed that architects will not be required to be familiar with the full syntax of i^* .

None of these approaches has offered a method to link business objectives to enterprise architecture. In addition, not a single one has investigated these techniques in reality with EAM frameworks. ArchiMate ([The Open Group \(2009a\)](#)) is the base language on top of which our approach will be defined. It has the advantage that architects have previously utilized it in practice.

Summary of the Literature Review Chapter with Guidance to the Remaining Chapters

The first Section (2.1) defined all aspects of the area of enterprise architecture. The second Section (2.2) described a number of EAM frameworks. The third Section (2.3) discussed a number of issues that motivated our selection of TOGAF as the basis of our solution. The fourth Section (2.4) offered an outline of the research area.

The following Chapter (3) offers an insight into the research methodology, Technical Action Research, driving our research. Chapter (4) presents the outcomes from the business survey carried out in order to understand the environment surrounding our action case study. The outcomes were important as they enabled us to refine our solution. We then identify the attributes of our Action Case Study, see Chapter (5). In addition, we document the identified requirement from the activities that we conducted to gather information from participant stakeholders about elements related to our research problem in order to enable the design, employment, and examination of our solution, see Chapter (5). Our solution is presented in Chapter (6) in the form of a methodology with an extended meta-model. Afterwards, we present in Chapter (7) the evaluation of our solution based on the employment's functioning and participants' remarks, followed by a self criticism of our endeavours. Chapter (8) concludes with discussion of future research points.

Chapter 3

Methodology

We used the principles of Technical Action Research (TAR) to drive our research methodology, wherein a solution is validated essentially by means of using it to treat a real-world problem. Our research methodology alternates over the two engineering cycles, which are proposed by TAR, to build a solution. The two cycles indicate the enterprise action cycle, i.e. Al-Elm, and the researchers' action cycle. Both have distinct goals and validation. The enterprise's goal is the evaluation of its redesigned EA in relation to its goals. The researcher's goal from the action case study is the validation of the proposed solution in relation to the solution identified goals.

According to TAR, we have three roles to perform: designing the solution, utilizing the solution to assist the enterprise, and learning from the experience. Designing the solution started by exploring potential approaches to gather principles, techniques, and concepts that meet our requirements. Then, we integrated the selected constituents to enable the utilization of distinct features offered by different techniques. Afterwards, there was a redefinition of the solution parts and the extended meta-model based on the usability needs. The redefinition of the solution was influenced by the existing practices of Al-Elm and its environment, see Chapter (4). This step resulted in simply including the smallest set of techniques and constituents that offered a useful and non-complex version of the solution. Utilizing the solution to assist the enterprise was achieved by carrying out an action case study in Al-Elm, see Chapter (5). We use the term solution to refer to our proposed methodology with the extended meta-model, see Chapter (6). Learning from the experience is concerned with observing the way we utilize the enterprise cycle to examine validation matters, see Chapter (7).

This chapter begins with a description of Technical Action Research and all its concerned aspects (3.1). After that, we offer the detailed description and discussion of our research methodology design, see Section (3.2). We then present the research methods that were part of our action research (3.3).

3.1 Technical Action Research (TAR)

In this section, we will first define technical action research, and explain why we have chosen to utilize its guidance for the purpose of this research, see Subsections (3.1.1, 3.1.2). Second, we will explain how we aim to generalize the outcomes of this research, see Subsection (3.1.3).

3.1.1 Definition of TAR

Technical action research (TAR) declares that the researcher participates in the form of three different roles (Fals Borda et al. (1991)): a ‘designer’ of the technique treating the problem, a ‘helper’ utilizing the technique to treat a problem of another party, and a ‘researcher’ reflecting on and depicting lessons learned about his technique. One recommended rule for a successful TAR methodology is to ensure the separation of these three roles. TAR was selected over other forms of action research owing to its appropriateness for our research area. The two engineering cycles of TAR enables the redefinition of our solution especially when it comes to the new constituents of our extended meta-model.

Technical action research suggests resolving a practical problem by applying some change to the real world. Action research uses the term ‘treatment’ to signify this change. The design of this treatment is structured after an investigation of the problem in the problem solving cycle, and before a validation, implementation, and evaluation respectively. The principle of the practical problem in action research is a distinction between the idealized assumptions of a planned solution, and the real world.

Technical action research involves a number of steps. The proposed treatment was applied to the identified problem. In addition, suggestions were offered to the enterprise regarding their system. During and after the appliance of the treatment, learned lessons will be produced about the treatment.

There are two key goals expected from this practice. First, the organization's aim is to treat the identified problem, where the practice took place. Second, the researcher's aim is to gain knowledge of any nature about their treatment. In short, it is carrying out a suggested solution of a problem and observing the achievement of that attempt, then attempting yet again if not fulfilled: *learning by doing*.

Action Research vs. Observational Study

In observational study, the organization will not be influenced by the study. In addition, the researcher's aim is to learn about the existing nature as it is presently occurring, bearing in mind that the ensuing awareness could be helpful to the organization, for instance, observing ongoing projects to examine certain features, while avoiding affecting these projects. Then, the researcher will be observing, analysing, and drawing lessons from the study. In contrast, action research goes beyond observation, and the researcher also intervenes in the organization, for example, with proposals for improvement.

Technical Action Research vs. Classical Action Research

- In the classical action research, the researcher assists the organization to recognise and solve a problem with the aim of being aware of the organization's situation.
- In the technical action research, '*the researcher aims to learn something about a technique by using it to solve a client's problem*' (Fals Borda et al. (1991)).

The strength of TAR is that it is superior to other proposals in the form of realistic validation. In other words, the best approach to gain knowledge of a technique is to apply it in reality. It is vital to scale up from desk to practice. The organization in which TAR takes place benefits from the free consultancy and the capacity to provide a positive outcome. It might also benefit from early awareness of learning about new techniques as well as community contribution through academia.

3.1.2 The Engineering Cycle of TAR

The structure of the engineering cycle has been extensively discussed in literature (Wieringa (2009)). The structure consists of five tasks:

1) Problem Investigation. This includes initiating criteria resulting from the identification of relative stakeholders and their goals. In addition, an investigation is carried out of all factors surrounding the problem. Furthermore, the criteria are compared in relation

to all surrounding factors. This offers the researcher with guidance of the requirements for the development. This is referred to as asking for phenomena that include stakeholders' questions.

2) Treatment Design. This includes designing a potential treatment that considers a problem context. This is helpful to abstract artefacts as it takes into account a number of possible treatments. Then it is used to interact with a problem context. An artefact can be any method, conceptual entity, business process, software, or hardware. An artefact refers to proposals. The treatment is the interaction of an artefact with the problem context, with the purpose of improving the context ([Hevner et al. \(2004\)](#)).

An example of the problem context is an enterprise comprising information systems and surrounded by environmental factors. Stakeholders and practitioners are part of the problem context too. Stakeholders refer to individuals influenced by the proposals. Practitioners refer to individuals designing treatments, such as the researcher. It is important to realize that the particular problem we address is part of a number of problem classes. Therefore, it is crucial to design the treatment with the objective of generalization. This ensues studying a particular problem to learn about a class of problems of comparable design. This highlights the importance of action research ([Lee \(2007\)](#)).

3) Design Validation. This task is concerned with questioning the expected effects on the problem context, and the expected value in relation to the identified criteria in the first task: 'Problem Investigation'. This is needed to offer validation of the treatment before its implementation. It acknowledges the presence of more than one effect, and partially satisfying the criteria.

In addition, there is a need to compare the treatment with other treatments, especially refined/smaller versions of the treatment. This is referred to as a trade-off question. Furthermore, here we question if the treatment would be applicable if the problem changes, especially when the problem is bigger, such as having a larger number of stakeholders. This is referred to as a sensitivity question.

4) Treatment Implementation. The treatment here is actually employed in the real world. This is done in our research by conducting an action case study, see Chapter (5).

5) Treatment Evaluation. Asking the same five questions we asked during the previous three tasks will enable the evaluation. They are asked after using the treatment in the real world. The questions are concerned with stakeholders' goals, expected effects,

expected value, trade-off, and sensitivity. The focus is different because we ask here for the effects under evaluation as opposed to asking for phenomena in theory. The effects of the employed technology in the environment will have an influence here, such as the open group architecture framework (TOGAF) ([The Open Group \(2009b\)](#)) in our case. TAR is a unique way to accomplish the validation task in the engineering cycle.

3.1.3 Case Based Generalization from TAR

This section will describe the nature of generalization from action case studies and how we intend to generalize from technical action research; see [Table \(3.1\)](#).

TABLE 3.1: Generalizing from technical action research

	General model of empirical scientific research	Model of action research
Researcher	Carrying out the model	Carrying out the model
Treatment instruments	The instruments to affect the object of study in a specific single way.	The instruments utilized by the researcher to assist the enterprise, such as training materials, tools, etc.
Measurement instruments	The instruments to observe the Object of Study; with avoiding an influence on it.	The instruments to observe what happened, such as a diary, logs, etc.
Object of study	Entity in reality to be studied by the researcher: A group of single or more population elements, such as sample, case, or model.	It will be the case enterprise, a single enterprise believed to be representative for a population of unobserved similar organizations.
Population	The studied entity.	All similar organizations.

There are two potential kinds of inference guiding the generalization: statistical inference and case-based inference. We depend on case-based inference in our action research.

Statistical inference is reasoning with reference to samples, where researchers will state assumptions on distribution and factors of the population as well as plan statistics on the sample afterwards. Then, researchers will examine observations to judge the assumptions.

The second kind of generalization is case-based inference, which is reasoning based on cases. The researcher will carry out two key activities: studying phenomena in a case that is structurally designed, and forecasting that some cases will demonstrate similar outcomes if they have similar architecture.

There are a number of attributes that distinguish this kind of generalization. First, reasoning will be driven from an observed case to a new case based on their similarity. Second, it must be determined under what conditions cases will be considered similar, as well as the consequences of this. Third, certain observations will be anticipated from similar cases. This is the kind of generalization that we intend to use in this study, see Table (3.1).

Architectural similarity of different enterprises that will represent potential cases will be determined by their entities-capabilities and relations of influence. In addition, it will be determined by the architecture's mechanism, which is how entities cooperate as a certain incentive has its effect. The last two statements will shape how architecturally similar two enterprises are. The architectural inference is valid and plausible by indicating that the mechanisms observed in a case will also happen in a similar unobserved case.

Therefore, we identified the architecture of the observed case to identify the influential applied mechanisms in order to infer. In addition, the observations are described in terms of identified mechanisms. Then, it will be deduced that architecturally similar enterprises with matching mechanisms will generate similar observations with no occurrence of conflicting mechanisms. Furthermore, we plan to offer further support in logic or formerly established theories.

The appliance of the same treatment to similar cases will have the same effect, unless certain threats occur to affect the validity. Different capabilities of architects and stakeholders will have a considerable impact. It will be affected if the EA in the first case is also influenced by other mechanisms. In addition, it might be affected if the treatment is non-deterministic or if the other enterprise employs more than one EAM technique.

3.2 Our Methodology Design

Technical action research (TAR) consists of two engineering cycles. The engineering cycle was explained in Section (3.1.2). TAR is the attempt to use a treatment in the real world by interacting it with a particular problem context, with the goal of improving the context (Baskerville (1997)). The researcher will attempt in the first cycle to improve a class of problems. The researcher will attempt in the second cycle to improve a particular problem (Baskerville (1997)).

The problem in the first engineering cycle is to improve our solution for enabling an EAM framework to be responsive to change. The first engineering cycle is called the researcher's cycle. The problem in the second engineering cycle is to validate our solution by using it to improve the business dynamic behaviour of the customized EAM framework implemented in Al-Elm in Saudi Arabia. The second engineering cycle is called the client or enterprise cycle, and its goal is to answer the validation questions in the first cycle.

In the second engineering cycle, we question the relevant stakeholders about their goals, contextual factors, and their evaluation of our employed solution. This results in a treatment plan between the relevant stakeholders and us. The researcher's knowledge at the start of this cycle is abstract. Therefore, it is possible that the desired effects might not be achieved or might be partially achieved. The importance of the treatment plan is to achieve the effects expected from the stakeholders by obtaining their knowledge to refine our solution (Kock (2007)). We then use our solution to improve the context in the enterprise, and evaluate the effects with the stakeholders of Al-Elm.

The goal of the client cycle is to answer one or more validation questions in the researcher's cycle. The early stages of the second cycle were used to simplify the contribution to the fundamentals which were found practical, sufficient, and not complex to achieve the desired outcome, in addition to validating the refined solution.

Subsection (3.2.1) describes the efforts involved in the five tasks of the two engineering cycles constructing the design of our research methodology. Subsection (3.2.2) presents how TAR has guided the distinction between the two cycles in the form of questions differentiating between knowledge acquisition and improvement efforts. Subsection (3.2.3) discusses how the principles of TAR offer an advantage in comparison with other form of action research. Subsection (3.2.4) outlines the need for the conducted action case study.

3.2.1 Our Two Research Cycles in TAR

In the first engineering cycle, we worked to answer knowledge-validation questions regarding stakeholders' goals, expected effects, expected value, trade-off, and sensitivity. In other words, we attempted to predict the possible outcomes if we employed our solution in practice (Lee (2007)). Both the first and second cycles follow the logical problem-solving structure of the engineering cycle, as explained in Subsection (3.1.2).

However, the objective of the first cycle (researcher's cycle) in TAR is to design and answer the identified knowledge questions (Kock (2007)). The results of this cycle are presented as the findings of the documents analysis, business survey and interviews in Chapters (4) and (5) respectively. These findings resulted from our endeavours before the actual employment of our solution.

We iterated over the stages of the cycles to clarify the corresponding activities in a methodical way for each different role drawn by TAR. The activities assigned with every stage for every role are explained next.

This second cycle is instigated from treatment validation in the first cycle. The second cycle is concerned with resolving how to refine the solution in order to satisfy stakeholders' concerns in the real world and also solve other problem contexts.

The following describes the efforts involved in the five tasks of the two engineering cycles constructing the design of our research:

The **first** task in TAR is the **research problem investigation**. We defined what is previously known about the five knowledge questions. This includes the scope, terminology, and current approaches of our unit of study. We offered abstract identification of elements enabling enterprises to face difficulties related to dealing with changing components. There was ongoing buildup of our knowledge, as we were not aware of many aspects at the starting stages of the research.

This continuing development of knowledge acquisition is part of this task over the iterations across the two engineering cycles. We were only limited to the features described in literature regarding different EAM frameworks' adaptation to change. One instance is the lack of awareness in regard to the customized approach of Al-Elm, specifically the outsourcing associations to used tools.

The **second** task in TAR is the **research design**. During the first cycle, we extracted from literature the initial set of constituents that can construct our extended meta-model, in addition to a number of alternative techniques that can participate in our treatment's design. A part of these attempts was presented in Chapters (2) and (5). We acquired Al-Elm's approval to conduct our action case study.

After starting the action case study, we communicated and approved the expected effects of our solution with the stakeholders of Al-Elm, which is in the second cycle. We also agreed on the means of data collection: interviews, logs, and a questionnaire. We discussed all aspects and the manner of these data collection methods. We agreed on improvement goals, treatment, and future reasoning.

Further discussions were held on how to be able to generalize from this action case study. The generalization considerations have affected the refinement of our solution during the 'research design' of the second cycle (Lee and Baskerville (2003); Seddon and Scheepers (2006, 2012)). Subsequently, we reduced the size of new constructs in the extended meta-model. We have opted to disregard many requirements that were elicited during the survey, see Chapter (5). Some requirements were overlooked for complexity reasons, while others were overlooked because satisfactory results were already reached with tools support. Other requirements were overlooked as they might affect the applicability of the solution to other cases due to capacity of extension.

The **third** task in TAR is the **research design validation**. During the first cycle, we generated the validation questions to guide the the validation of the solution, see Section (3.2.2). The predicted answers of the questions raised in the first cycle will be validated.

During this task in the second cycle, we tried to answer accurately the expected validation questions, as we were about to execute our research-design regarding stakeholders' goals, expected effects, expected value, trade-off, and sensitivity. We gathered and analysed the requirements, presented in Chapter (5), to build our solution. We investigated contextual factors and how they are representative of similar problems. We also explored how to adapt the solution for enabling integration in practice.

The **fourth** task in TAR is the **research execution**. This research execution task in the first cycle has instigated the execution of the second engineering cycle (client cycle). We carried out all efforts to transfer our solution into practice.

In the second cycle, the previously approved treatment plan, during the research design task, is carried out. We decided on the participant stakeholders, time slots, and resources. The action case study is conducted in which we used our solution to improve the problem context in Al-Elm. The participant stakeholders will be the main element in the evaluation of the second engineering cycle, as they reflected to what extent the treatment has achieved its desired effects.

The **fifth** task in TAR is the **result evaluation**. During the second cycle, we gathered the answers to our questionnaire. We documented our observations on the employment and any consequences for improvement. In addition, we requested explanations for a number of stakeholders' efforts that can be part of beneficial knowledge.

After concluding the second engineering cycle, we started the research evaluation task in the first engineering cycle. We analysed the logs, remarks, and questionnaire in order to form learned lessons. We studied potential alternative explanations. We extracted observations regarding generalization. We identified all possible limitations of our findings and subsequently limitations of our research methodology as a whole, see Chapter (7).

We stated the possibility that challenges might be associated with other stakeholders employing the solution on their own, which is a risk associated with TAR. This is lessened by the supported guidance that we described in Chapter (6). We encouraged participant stakeholders to offer truthful remarks even if they are negative. This is to avoid only providing favourable feedback, which is a risk associated with TAR.

We have offered the requirements specification of problem investigation concerning the environment in Chapter (4). The first cycle of the treatment design is offered in Chapter (5), specifying the requirements of an improved EAM function addressing the concerns of dynamism. The actual design of the treatment is described in Chapter (6). The validation is described in Chapter (7).

3.2.2 TAR as an Artefact-Driven Approach

Technical action research (TAR) is a form of action research; it is an artefact-driven rather than a problem-driven approach (Kock (2007)). The goal of TAR is to raise the relevance of artefacts. This is in contrast to other forms of action research that seek to raise the relevance of knowledge. In other words, TAR aims to bridge the relevance gap between

idealized and practical conditions (Lee (2007)). This is important for developing the idealizations of preliminary design into the actual conditions of practice.

We approached the problem solving in the nature of an engineering cycle in which desired features of our solution are evaluated against stable goals, as recommended in Schon and DeSanctis (1986); Wieringa (2009), see Section (3.1.2). This enabled us to reach logical refinement of our solution by evaluating alternative components against design goals.

TAR proposes the use of two engineering cycles; we assigned idealizing assumptions about our planned solution in the first cycle. This implied a more complicated and broad meta-model. We gradually relaxed the initial assumptions by analysing the findings from the business survey. Therefore, we improved our solution by iterating through the cycle. This is followed by actually employing our solution in the action case study by iterating over second engineering cycle.

The need for more than one engineering cycle in TAR is to offer a well-defined distinction between the first cycle in which we develop our solution that starts by knowledge acquisition, and the second cycle in which we employed our solution with the aim of solving a problem in the enterprise (Kock (2007); Lee (2007)). Therefore, we used this distinction proposed by TAR to guide our research.

The distinction between the two cycles appeared in the form of questions differentiating between knowledge acquisition and improvement efforts. Knowledge acquisition questions are formulated to describe the current state of EAM frameworks and predict how it can be developed. We formulated the questions about knowledge acquisition to drive our first cycle as follows:

- To what degree do enterprises model their EA–EAM progression?
- What are the main difficulties facing EAM?
- How are initiatives' goals and attributes gathered?
- What are the development levels of initiatives' goals and attributes gathering?
- Which events within the EAM function will cause changes in high-level goals?
- What are the implications of handling dynamism manually?
- How do enterprises operate when it comes to gathering data from stakeholders?

- Are there any attempts to develop or utilize automated solutions, rather than manual, across enterprises?
- What are the desired features of an improved EAM function guiding the solution/extension?
- What are the expected effects of integrating a new technique to enable dynamic consideration to change?

Our efforts of knowledge acquisition are conducted first in the form of a business survey across a number of enterprises, see Chapter (4), and second in the form of interviews questioning participant stakeholders about the context of EA in Al-Elm to generate guiding requirements, see Chapter (5). This has enabled the refinement of our solution in particular when it comes to reducing the number of new constituents in our extended meta-model, see Chapter (6).

Questions about improvement efforts aim to refine the solution based on practical guidance extracted from the answers of knowledge acquisition questions. We formulated the questions about improvement efforts, to drive our second engineering cycle. Our questions are presented next:

- By what means can we ideally support the constant stakeholders' need for information that is governed by the particular business behaviour/context of their enterprise? Our solution addresses concerns related to this question in Sections (6.3, 6.5) in Chapter (6).
- By what means can we ideally enable building EAM models reflecting constant change in business behaviour and goals, and consequently improving the planning of target EA states? Our solution addresses concerns related to this question in Section (6.3) in Chapter (6).
- By what means can we ideally produce an EA landscape reflecting the different mental models of stakeholders? Our solution addresses concerns related to this question in Section (6.4) in Chapter (6).

Our development efforts that reflect the previous questions are presented in Chapter (6). We proposed a methodology addressing the needs extracted from survey and interviews, which are presented in Chapters (4) and (5) respectively. The methodology is supported by an extended meta-model enabling the representation of new constituents, see Chapter (6).

TAR manages the validation of new treatments under conditions of practice (Davison et al. (2004)). TAR allowed us to learn how our solution performed in practice. A number of research projects have used the design of TAR, such as Morali and Wieringa (2010); Zambon et al. (2011). TAR enables validation by offering a planned checklist of development guidance through the use of two engineering cycles.

Validation seeks to answer questions about knowledge acquisition and improvement efforts. This guides answering usefulness and dynamism questions about our solution in context, which is followed by investigation of trade-off and sensitivity analysis.

3.2.3 Comparison of TAR and Other Forms of Action Research

Action research in its different forms follows the cycle introduced in Susman and Evered (1978), which involves the following tasks: problem diagnosing, action planning, action taking, evaluating, and specifying learning. TAR proposes a multilevel structure that overlays the general action research cycle.

The cycle proposed in Susman and Evered (1978) is driven from the problem in reality. It is a bottom-up development starting from the enterprise's problem and iterates through the previously mentioned tasks until the learned lessons enable generalization. The cycle focuses on the enterprise's infrastructure wherein the researcher and the client join their efforts to solve the problem and learn from it. In addition, 'action design research' proposed in Sein et al. (2011) is problem driven too.

Instead, TAR differs as we identify a class of problems first, which is EAM framework's perceptive of change. And then we work to develop a solution to deal with the dynamic business behaviour of an enterprise. Unlike general action research where the cycle has one client (the host enterprise), TAR has more than one client in more than one cycle (the researcher's cycle and enterprise's cycle). Therefore, TAR is an artefact-driven approach rather than a problem-driven approach.

TAR satisfies a number of principles: First, a client–researcher agreement is required for every cycle; these were agreed with the research and development unit (RDU) at Al-Elm. Second, each cycle can be executed iteratively for a redesigning purpose; in other words, TAR follows a cyclical model. Third, TAR starts and ends by using theory; it starts from literature investigation and ends by offering a learned lesson for generalization.

Fourth, TAR is developed on the basis of change through action, by improving our solution in one cycle and improving the enterprise's context on the other. Fifth, TAR aims to realize learning through reflection on action. This can be achieved by introducing a research cycle in the design between the two engineering cycles of TAR. This research cycle aims to reflect and analyse the outcomes from the client or researcher's cycle, depending on whether you choose a bottom-up or top-down approach. Then, we answer validation questions to reach learned lessons about the employment of our treatment in practice and how to improve it.

These earlier principles were first introduced in Davison et al. (2004) as the principles of canonical action research, but it differs from TAR as it follows a problem-driven approach.

3.2.4 Action Case Study

The validation of the proposed solution will need to examine its usability by enterprise architects. The advanced issue of usefulness is only addressed if we establish the usability of the solution.

There is just one means of answering the usability questions: EA architects utilizing this proposed solution while we observe the way architects complete the employment, in view of the fact that the proposed solution will not be placed into a realistic perspective unless we transfer it into a practical environment. Therefore, we needed to carry out an action case study. The first step, in this action case study, is to transfer knowledge of the proposed solution to an enterprise followed by an observation of the utilization of this solution.

This action case study was conducted at a large national company that is called Al-Elm, *'owned by the Public Investment Fund (PIF), the investment arm of the Saudi Arabian Ministry of Finance'* (Elm). Al-Elm provides services to enterprises in the private sector. The annual budget obtainable for these developments is in excess of one billion pounds. Al-Elm employs about 2000 employees spread over a number of cities in Saudi Arabia.

The action case took place from March 2014 to November 2014, with the feedback and remarks process extended to June 2015. Communication in relation to the evaluation of the solution continued for a longer period. An official authorization to carry out this case was granted; it was organized during the six months prior to the start of the case study. King Saud University was the coordinator between Faisal Almisned and Al-Elm. The approval involved a one-year full collaboration with RDU at Al-Elm. An internal assessment from the company was in place. Al-Elm was expected to be a model environment for such

a case study. In addition, Al-Elm employs EAM throughout its hierarchy, utilizing a customization of TOGAF.

Related stakeholders include IT architects, directors, and analysts, because they are searching for a means to demonstrate the importance of their EA design to business stakeholders. In addition, it involves stakeholders who are searching for a means of studying the influence of change in business objectives on the architecture design.

The case study involved a number of pre-identified tasks. These tasks are as follows:

A number of training sessions were given, on the proposed treatment, for each group of stakeholders involved directly in the case study. This was done by attending meetings of several departments and a number of development teams.

We were involved in one-to-one discussions with EA architects in Al-Elm to grasp the business context of the enterprise. In addition, we collectively constructed a number of treatment models of their business objectives and their associations with up-to-date architecture. Architects were able to perform this on their own, by analysing business documents of Al-Elm. Small workshops were conducted to provide a full analysis of business goals. We helped in this task but it was not mandatory.

We arranged scheduled weekly meetings in order to review the constructed solution and to offer and receive suggestions.

Discussions were documented, especially the discussions between the architects themselves. Data collection was performed while gathering documents created by architects. In addition, data collection was completed by producing notes throughout the discussions. If there was an opportunity to gather observations by means of questionnaires or interviews, this was done and was crucial. However, this was determined by time availability of the suggested stakeholders.

We have thoroughly examined the documentation inside the enterprise to understand their business practices and EAM best past practices.

Numerous interviews for the purpose of getting feedback were conducted. Questionnaires were handed out and detailed discussions were held to understand their remarks.

A form of online survey for representatives across different enterprises was undertaken for the first part of the case study.

3.3 Research Methods

This section describes the main research methods elected to be utilized throughout our research design. The sections explain the endeavours involved in each one of these research methods.

3.3.1 Documents Analysis

This stage started before the actual commencement of the action case study, as relevant documents were sent in from Al-Elm. This has granted me the chance to examine the documentation of the actual practices within the studied enterprise. However, it has to be considered that undocumented practices that were reserved in the minds of stakeholders were unattainable at the earlier part of this stage. A later part of this stage was conducted within the enterprise where the case study took place.

An examination took place of the documentation of past best practices inside the enterprise. We presented a dynamic set of potential methods to tackle the problem. In addition, we were advised to offer an extensive examination of challenges and desired features, see Chapter (5).

3.3.2 Interviews

Interviewing is a suitable procedure to realize the contextual elements surrounding a situation from the perspective of other cooperating participants. The key benefits of interviews include direct communication with participants, the ability to obtain the required input that was relevant in practice, and the opportunity to grasp, from the minds of participants, practices that are not documented. The drawbacks of the interviews include the time requirement and the challenge of encouraging participants to be involved and to be eager to express their ideas (Elliot (1991)).

In the early stages of the case study, we used semi-structured interviews with key personnel. We first discussed the business survey and how to gain the maximum benefits from its feedback. After agreeing the form and contents of the business survey, the RDU at Al-Elm distributed it to the participating enterprises in Saudi Arabia, see Chapter (4).

We then started by determining the area of interest and investigated the problem from the literature. After that, we allowed the participants to raise related contextual elements and concerns. We encouraged the interviewees to describe and clarify any relevant issues (Whyte (1991)). This enabled the continuous refinement of the problem and the particular requirements of proposed improvements, see Chapter (5).

These semi-structured interviews focused on participants' knowhow, and aimed to extract undocumented details. These interviews involved a number of tasks: selecting participants, initial explanation of the research, carrying out interviews in an assuring manner for the interviewees, recontacting participants regarding unresolved issues, and analysing the collected information to review and change our solution.

A number of stakeholders during meetings disputed the suggested structure of a number of proposed techniques, highlighting some conflicts with the used tools. We argued that the examination of such advanced points of comparison with tools practices is appropriate for further research. The RDU utilized business process models and notation as a temporary means of visualization.

A main strength is the constant refinement and redesign of the problem, questions, and proposals. This contribution is based on the literature and on the outcomes of meetings. The early set of meetings focused on understanding existing practices within the enterprise.

Consequently, the proposed solution was discussed in one-to-one meetings. The final cycle of refinements included mapping the proposed techniques to the business-behaviour of the enterprise. The interviews have resulted in naming information sources and change generator sources as well as what should be considered processParts, and what to expect as productParts.

After the employment of our solution, we used the structured interviews to guide the participants' input in the same direction, based on the produced questionnaire, see Appendix (A). This facilitated the feedback to be gathered consistently and analysed in order for evaluations to be reached, see Chapter (7).

3.3.3 Business Survey

We utilized a business survey to facilitate the attainment of information about actions, circumstances, or observations about the environment surrounding our action case study. Assessable questioning was utilized to reach interpretations from the collected data concerning identified situations. This enabled us to examine additional issues about the current state of EAM in Saudi Arabia over what is usually achievable in theory. The gathered information reflect practices within their real environments.

A drawback of the survey method used is the inability to grasp insights about the triggers of initiatives partaking in the investigated problem. In addition, surveys can be influenced by a number of causes of partiality; for example, the influenced sourcing of participants, the timing of survey distribution, and the effects of survey design by the researchers' interpretation.

The ability to offer a new solution within a structured environment should start with practical observation of all the factors surrounding the problem and full understanding of factors influencing the success of the solution. Therefore, we have started with understanding these aspects before implementing the solution. This was done through observation of current practices within the environment where the action case study took place.

In addition, we analysed the feedback gathered from participating enterprises. We enquired about a number of issues concerning the team structures, collection processes, and data collection triggers.

We aimed to reach outcomes outlining an inclusive observation of current practices and contextual factors that are relevant to the problem of our research and associated challenges.

The survey was designed to describe the activities enabling initial examination of the research problem and the initial set of proposed methods to address the problem. The outcomes of the business survey facilitate redesigning the proposed solution with the aim of reaching the best approach to how the research objective should be addressed.

We were granted the opportunity to examine the state of EAM across different EAM divisions of major Saudi Arabian enterprises, see Chapter (4) for more details. This took place with the collaboration of the RDU at Al-Elm. This was crucial to understand the environment surrounding EAM and the main challenges facing enterprises in the region.

We designed our survey to also investigate the significance of our research problem and its applicability, see Chapter (4) for more details. Most of our participants were very accustomed to EAM. In addition, the environment surrounding their corresponding organization is well known to them; selected participants answered enquiries for their enterprises.

The RDU at Al-Elm helped us in identifying the participating stakeholders across different enterprises. The survey was publicized on a well-known government website. A large number of emails were sent to raise awareness of the survey and to invite stakeholders associated with EAM across various enterprises utilizing EAM frameworks. One stakeholder from each enterprise participated. The survey was completed by 16 enterprises; a list of the participating enterprises is given in Chapter (4). A small number of the chosen enterprises did not complete the survey. Chapter (4) illustrates the division across enterprises involved in our survey, i.e. which industry sectors.

The participants in the different enterprises were asked to answer the following questions to form our empirical examination of EAM practices in Saudi Arabia regarding the following areas of concern:

- A.1: Number of years working with EAM frameworks?
- A.2: Number of enterprises where you have experienced working with EAM frameworks?
- A.3: Nature of interaction with EA?
- A.4: Familiarity with which EAM framework?
- A.5: Is there any own solution built within the organization?
- A.6: Modelled state of the EAM function in organizations?
- A.7: Key challenges in enterprise architecture management team organization?
- A.8: How are the teams for the EA data collection organized?
- A.9: How is manual EA data collection organized? Type of collection? (Multiple choices were possible)
- A.10: Does your organization have a dedicated and specified process description for the data collection? (Process available)
- A.11: Has your organization implemented some form of structured maintenance for EA models? (Automation)

- A.12: What are the triggering events for updating contents of your EA models? (Multiple choices possible) (Triggering events)
- A.13: What are the key EA maintenance challenges in your organization?
- A.14: How is structured maintenance of EA models technically implemented in your organization? (Multiple choices possible) (Implementation)
- A.15: Do you consider the need for further assessment for requirements analysis functionality a necessity for improved EAM functionality?
- A.16: Have the tool selection process and analysis activities of the EA required IT involvement?
- A.17: Would you advise your organization to develop its own customized software solution to deal with the challenges of EA models maintenance?
- A.18: Which one of the following you would consider the best option to handle the current limitations of your EAM framework?
- A.19: Which one of the following would you consider pivotal to the business requirements analysis part of EAM? (Multiple solutions)
- A.20: What would be considered the key to future success of upcoming solutions? (Multiple solutions possible)
- A.21: What are the current practices used for documentation in organizations applying EAM?
- A.22: During the implementation of new initiatives, was there any missing data associated with the new initiative's requirements?
- A.23: What are the effects of implementing multiple solutions that treat the same sub-requirements?
- A.24: In your organization, who is in charge of making decisions regarding new solutions?
- A.25: What are the main needs you believe will help in achieving high level goals?

The form of questions with their identified responsive answers are given in the Appendix, see ([A](#)).

3.3.4 Questionnaire

Questionnaires are considered a fast and direct procedure to gather extensive information from participants. It offers a base to extract participants' thoughts and reflections on a set of circumstances and initiatives ([Elliot \(1991\)](#)).

We have used a controlled form of questionnaire by handing out the questionnaire during interviews with participants and allowing participants to enquire about questions. A number of questions involved open responses, which enable participants to clarify their thoughts and suggestions; an example is question A.20 in ([A](#)). We have used scaled questions offering different statements to select the most relevant statement; an example is question B.6 in ([A](#)).

In addition, we used multiple-choice questions offering a group of pre-identified alternatives; an example is question A.14 in ([A](#)). Moreover, we have utilized some open questions that offer an open answer with freedom for the participants to explain their reflections; an example is question A.25 in ([A](#)).

There are key benefits of the utilized questionnaire including fast completion, as well as simplicity of analysis and further investigation. Another benefit was offering comparative evaluation of different perspectives, which facilitated the information to become assessable ([Darke et al. \(1998\)](#); [Liamputtong \(2013\)](#)).

The drawbacks of the questionnaire are the time requirements for investigation and wide-ranging research to offer inclusive, direct, and applicable questions. Another challenging and time-consuming task is designing questions that examine offered solution in line with the understanding of participants as well as their ability to express their thoughts, rather than directing their answers.

The analysis of the questionnaire outcomes presents the evaluation of our solution in line with TAR principles, see Chapter ([7](#)). The proposed solution was evaluated by practitioners' questionnaires and interviews during the action case study at Al-Elm. The participants sample involved a number of architects, analysts, management individuals, and EAM consultants.

After producing the initial draft of the questionnaire, we asked two uninvolved highly experienced members of the RDU at Al-Elm to complete the questionnaire; this was a pre-examination step. Afterwards, their feedback was taken into consideration to improve

the questionnaire. Other measures were taken to ensure the correctness of the questionnaire; it was distributed among the supporting RDU staff at Al-Elm and it was presented in meetings for feedback.

The participants within Al-Elm were asked to scale their satisfaction of the solutions' employment to the degree of their participation. All of their feedback was in line with their roles as stakeholders in the enterprise in relation to the following points of concern, see Chapter (7). All of the following points of concern were the result of the analysis of the outcomes from our research methods: documents analysis, interviews, business survey, and questionnaire.

- B.1: Clear and managed responsibilities
- B.2: Developing initiatives and templates
- B.3: Flexibility throughout execution
- B.4: Visibility of initiative progression
- B.5: Observable development of initiative
- B.6: Transparency and visibility of initiative goals
- B.7: Hierarchical structure of activities
- B.8: Clear and simple assignment of responsibilities and roles
- B.9: Integration of attributes to the initiative
- B.10: Identification of rational dependencies across activities
- B.11: Comprehensible and flexible for business stakeholders
- B.12: Flexibility of enabling new roles and stakeholder at run-time
- B.13: Identification of temporary and preconditions
- B.14: Availability of guidelines
- B.15: Business stakeholders' adaptation at run-time
- B.16: Projection of drafts of future landscapes
- B.17: Multiple states identification
- B.18: Business stakeholders' adaptability to future states
- B.19: Visibility of application landscape roadmap
- B.20: Visible views for different stakeholders concerns
- B.21: Trilogy of associations

- B.22: Visualization of business support providers
- B.23: Inference of target landscapes
- B.24: Landscape variation
- B.25: Traceability of stakeholders' decisions
- B.26: Classifying divergent and convergent initiation phase
- B.27: Collecting participation from diverse stakeholders
- B.28: Meta-modelling with the intention of generalization and learning
- B.29: Maintaining simplicity and transparency
- B.30: Validating with data
- B.31: Implications on productivities
- B.32: Landscape maintenance
- B.33: Progression of EAM function
- B.34: Minimizing expenses of the enterprise
- B.35: Preserving activities within the boundaries of model's objective

3.3.5 Ethical Considerations

This section discusses the ethical aspects associated with our action case study. The following points explain the nature of our action research¹ interactions with individuals:

- Our action research did not share or handle any personal information. There was no risk to any participant that can be associated with participation in the research.
- Al-Elm is the enterprise where the action case study was conducted. This research study was organized by King Saud University, because King Saud University sponsors my PhD study.
- There is no financial incentive for the researcher, Al-Elm (as a cooperative enterprise), or to the participants in this research. There is no financial interest for the department or the researcher arising from this study.
- Key personnel in Al-Elm were invited to provide valuable input of the importance of their EA design to business stakeholders. The selected personnel should be familiar with the influence of change in business objectives on architecture design. They were selected based only on their expertise and involvement in such initiatives.

¹For better readability, our use of the term 'action research' throughout the thesis implies TAR.

- The participation in this study was voluntary. All participants had the chance to withdraw without providing any reason. All participants were kept anonymous.
- An information sheet of the study was distributed to all individuals whose work was relevant to the study within Al-Elm. The information sheet offered a brief explanation of the study. The information sheet of our action case study is presented in Figure (3.1).
- We held meetings to develop our intended study and to answer any question arising about the study.
- The signed consent form for our study is in line with informed consent forms not dealing with medical research, children and young adults, people with learning difficulties, crime, and/or military forces. The consent form of our case study is presented in Figure (3.2).
- The aim of the study was to propose an extension to the underlying meta-model in order to provide additional representation capability enabling the description of proposed techniques and practices. We aim to propose a development methodology enabling a responsive representation of the progression of EA states, in regard to changes and improved planning. All proposed techniques were governed by a methodology assembling these techniques and enabling enterprises to pick techniques adapting their contextual needs. We aimed to empirically examine the employment of such proposals in practice. We aimed to enable joint understanding of business behaviour affecting the modelling of initiatives. We aimed to observe all aspects associated with such application in practice. This involved a questionnaire-based interviews with the staff of the enterprise.
- There was no collection of any sensitive data. Interviews involving the questionnaire formed the main measurement and feedback method. The signed consent form was stored separately from the responses provided.

FIGURE 3.1: Information sheet.

6 – 01-02-2015
Information Sheet
Title of Study: Extending the Capacity of Enterprise Architecture Management Frameworks: Towards a model-driven handling of Dynamics Name of Researcher: Faisal Abdulaziz Almisned, Faculty member at King Saud University, PhD candidate at King's College London under the supervision of Professor. Peter McBurney. Contact Details: Email: faisal.almisned@kcl.ac.uk You may retain this information sheet for reference and contact us with any queries. I would like to invite you to participate in this research study which forms part of my PhD research. You should only participate if you want to; choosing not to take part will not disadvantage you in anyway. Before you decide whether you want to take part, it is important for you to understand why the research is being done and what your participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask me if there is anything that is not clear or if you would like more information. The aim of the study is to propose an extension to the underlying meta-language in order to provide additional representation capability enabling the description of proposed techniques and practices. We aim to propose a development method enabling a responsive representation of EA states progression, in regards to constant changes and improved planning. All proposed Techniques are governed by an adaption methodology assembling these techniques and enabling enterprises to pick techniques matching their contextual needs. We aim to empirically exam the employment of such propositions in practise. We aim to enable joint understanding of business-behaviour affecting the modelling of initiatives. We aim to observe all aspects associated of such application in practise. This will involve a questionnaire-based interview with you. I am inviting key personnel in Al-Elm that provide a valuable input of the importance of their EA design to business stakeholders. The selected personnel should be familiar with the influence of change in business objectives on the architecture design. If you decide to take part you will be given this information sheet to keep and will be asked to sign a consent form. At a time convenient for you, I will then call you to discuss the interview procedure with you. On request you will be given the interview topic guide. With your consent, I will arrange to interview you to document your feedback. There is no financial incentive to participate in this research. There are no foreseeable risks in participating in the study. The main disadvantage to taking part in the study is that you will be donating around an hour of your time to take part. There are no direct benefits to taking part. However, the information I get from the study aims to methodologically design and develop a set of propositions optimising the practices of enterprise architecture management. Furthermore, I will provide you with a summary of a final report describing the main findings, including good practice and innovative initiatives. Your participation is entirely voluntary. If you change your mind, you are free to stop your participation without giving any reason at anytime. In reporting on the research findings, I will not reveal the names of any participants. Thank you for reading this information sheet and for considering taking part in this research.

FIGURE 3.2: Informed consent form.

4 – 14-02-2015

Informed CONSENT FORM

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research. You will be given a copy of this Consent Form to keep and refer to at any time.

Thank you for your interest in taking part in this research. Before you agree to take part, the person organising the research must explain the research study to you.

Title of Study: Extending the Capacity of Enterprise Architecture Management Frameworks: Towards a model-driven handling of Dynamics

I, the undersigned, agree that:

- I confirm that I have read and understood the information sheet dated [5 – 01/02/2015] for the above study. I have had the opportunity to consider the information and asked questions which have been answered satisfactorily.
- I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.
- I consent to the processing of my personal information for the purposes explained to me. I understand that my input may be subject to review.
- I understand that confidentiality and anonymity will be maintained and it will not be possible to identify me in any publications.
- I agree that the research team may use my input for future research.
- I understand that the information I have submitted will be published and I wish to receive a copy of it.
- I agree that the research study named above has been explained to me to my satisfaction and I agree to take part in this study.

Name of Participant	Date	Signature
Name of Researcher	Date	Signature

Summary of the Methodology Chapter with Guidance to the Remaining Chapters This chapter presented our research design and methods. It described how our solution was systematically developed and examined. We defined Technical Action Research and all its concerned aspects (3.1). After that, we offered the detailed description and discussion of our methodology design, see Section (3.2). We then presented the research methods that were used in our research (3.3).

The following Chapter (4) presents the outcomes from the business survey conducted to gather the aspects surrounding our action case study. We then illustrate the endeavours we carried out to continuously develop, redefine, and improve our solution during the early stage of our action case study, see Chapter (5). Our solution is presented in Chapter (6). Afterwards, we outline in Chapter (7) a comparison of the stakeholders' evaluation of EAM practices with and without employing our solution. Chapter (8) presents a conclusion.

Chapter 4

Business Survey

In this chapter, we present the outcomes from the business survey we conducted in Saudi Arabia to examine enterprise architecture management (EAM) practices regarding our areas of concern, see Section (4.1). It offers an examination of the current state of EAM practices in Saudi Arabia, which is a contribution of our action research. The business survey aimed to study the contextual factors surrounding EAM practices in relation to changing business behaviour. This supported our gradual development of the proposed solution in our development cycle. Section (4.1) illustrates the significance of our identified problem.

In this action research, we offer a methodology providing guidance, techniques, and an extended meta-model to support EAM functions to cope with changing business behaviour in enterprises. We approached our goal and offered a methodology, a development on top of core EAM functions. In Chapter (6), we describe our proposed methodology with the extended meta-model. We explored ways to create elements of EAM frameworks able to cope with dynamic environments and developed them practically via an action case study, see Chapter (5). Our solution was evaluated by means of an action case study within a semi-governmental enterprise in Saudi Arabia called Al-Elm.

4.1 Outcomes of the Business Survey

The ability to offer a new solution within a structured environment should start with practical observation of all factors surrounding the problem and full understanding of factors influencing the success of the solution. Therefore, we have started by identifying these aspects before implementing the solution. This was done through observation of current

practices of EAM in the same environment where the action case study took place. We use the term solution to refer to our proposed methodology with the extended meta-model.

In addition, we analysed the feedback gathered from stakeholders in participating enterprises in Saudi Arabia. We have enquired about a number of issues concerning the team structures, collection processes, and data collection triggers. Table (4.1) covers the issues we have enquired about surrounding the problem.

Subsection (4.1.1) links the concerns of our action research with outcomes of the business survey. Table (4.1) illustrates the remaining parts of this section.

The answers demonstrate that manual gathering of business initiatives' goals, tasks, and attributes is up till now the most common method of data collection. Business behaviour consists of business initiatives' goals, tasks, and attributes, in addition the the events triggering a change. The answers also confirm that the maturity of the majority of utilized gathering processes for the maintenance of enterprise architecture (EA) models is by and large very minimal.

A group of questions were designed to enquire about each one of the investigated issues in our business survey, the issues are listed in Table (4.1). The list of all the questions are presented in Appendix (A).

We designed our survey in a way that facilitates the extraction of existing practices and how they address current difficulties. The way we designed and conducted our survey is directed at examining our methodology. Moreover, the survey consisted of specific parts designed to elicit current practices when it comes to the scope of this action research.

TABLE 4.1: Overview over the main investigated issues in the business survey

Issue	
What are the industry sectors of the involved enterprises in our business survey?	See Table (4.2)
What are the roles of the participating stakeholders within their enterprises?	See Table (4.3)
What are the participants' expertise and degree of involvement?	See Table (4.4)
To what degree do enterprises model their EA–EAM progression?	See Table (4.5)
What are the main difficulties facing EAM?	See Table (4.6)
What are the gathering techniques of goals, tasks and attributes of business initiatives?	See Table (4.7)
What are the development levels of EAM models maintenance?	See Table (4.8)
Which change-generators/events within EAM function will cause changes in EA Models?	See Table (4.9)
What are the implications of handling dynamism manually?	See Table (4.10)
How enterprises' stakeholders communicate to change the representation of business behaviour?	See Table (4.11)
Are there any attempts to develop or utilize automated solutions, rather than manual, across enterprises to update EA models?	See Table (4.12)

4.1.1 Reflection on the Concerns of Solution

The business survey was designed to validate the core problem addressed by this research. We questioned the existing practices surrounding dynamism. We attempted to align, affirm, and drive our implied concerns which were built on an examination of the literature review as explained in previous chapters. The implied concerns were in line with the answers of our abstract research question. The following outlines and links our implied concerns with outcomes of the business survey.

The outcomes illustrate that enterprises face different EAM difficulties. One fundamental difficulty appears to be EAM's handling of dynamism when it comes to achievement of high-level goals. This materializes by indications that a large number of EAM initiatives battle to represent dynamism of business behaviour and the implication on high-level goals.

The resulting data set shows that 77% of stakeholders asserted the high level of labour needed to gather data in order to represent business behaviour implications on high-level goals, otherwise the data will be shown to be of poor quality. The contribution of this research ensures the offering of empirical grounds for maintenance concerns of EA models. In addition, practical indications stressed that the kind of team organization has an impact on the quality of represented data. This is clearer when federated EAM teams are compared with centralized EAM teams, which shows improved data quality with federated teams.

In relation to the evolution of EA states, we can confirm that successful EAM representation efforts need support to tackle dynamism issues. In our action case study, we obtained important outcomes associating incidents where insufficient mechanism support has occurred with a number of wasted manual efforts of EAM data gathering being detected. Of the 57 questioned stakeholders, 78% declared unsatisfactory support of the framework used for maintenance of EA models, while 83% also declared the need for additional tasks to gather and link changing business behaviour to high-level goals in EAM representation.

In addition, of the 22% stakeholders that do not state unsatisfactory support, 47% of them declare the need for greater efforts to face the changing nature of business behaviour. Therefore, this indicates that whenever stakeholders state the need of greater efforts to face the changing nature of business behaviour, this can be an indication of unsatisfactory framework support for dynamism. As a result, we can confirm that the need of higher efforts is a major concern for EAM.

The utilization of an extended meta-model was suggested to reduce the required efforts of EAM representation. Our action case study compared the data gathered from stakeholders who have applied our offered solution; they have not similarly criticized the gradual and prolonged nature of EAM representation. Of stakeholders who have not applied a new mechanism, 65% of them criticized the efforts required to gather and represent changing business behaviour.

Of participants involved with the 17 initiatives where the solution has been employed, only 25% criticize the same concern. This signifies that our solution truly has an encouraging impact on the gradual and prolonged nature of EAM representation. Therefore, our action case study outcomes validate that the utilization of our solution decreases the need of higher efforts to address dynamism in business behaviour.

To sum up the outcomes of our survey, we can assert that the proper representation of dynamism in business behaviour is still a key concern in the majority of enterprises. In addition, the causes of this concern originate from the slow manual gathering techniques, the lack of time-knowledge representation capacity, and the missing of communication and agreement between involved stakeholders. Therefore, the outcomes of the business survey are in accordance with [Ahlemann et al. \(2012\)](#); [Buckl et al. \(2011c\)](#); [Farwick et al. \(2012\)](#); [Luna-Reyes and Andersen \(2003\)](#); [Sterman \(2000\)](#); and [Wagter et al. \(2005\)](#).

4.1.2 Diversity of Participating Semi-Governmental Enterprises

The research and development unit RDU at Al-Elm helped in identifying the participating stakeholders across different enterprises. One stakeholder from each enterprise has participated. The survey was completed by 16 enterprises, a list of the participating stakeholders' enterprises is given in the following paragraph. A small number of the chosen stakeholders did not complete the survey. Table (4.2) illustrates the division across enterprises involved in our questionnaire, i.e. which industry sectors. Financial enterprises represent the leading sector with 42%; after that, technological enterprises with 29%, and then pure governmental enterprises with 29%. EA can simply be seen as a strategic IT-management topic.

TABLE 4.2: What are the industry sectors of the involved enterprises in our business survey?

Industry	Number of enterprises	Percentage
Technological enterprises	4	29%
Financial enterprises	6	42%
Governmental enterprises	4	29%

The participating financial enterprises are: Alinma Bank, Public Investment Fund, SAGIA, Capital Market Authority, Tadawul, and Saudi Arabian Monetary Agency. The participating technological enterprises are: Al-Elm, National Information Centre, Communications and Information Technology Commission, and Advanced Electronics Company Limited. The participating governmental enterprises are: Saudi Food and Drug Authority, Bureau of Investigation and Public Prosecution, General Authority of Civil Aviation, and the Saudi Commission for Tourism and Antiquities. It should be noted that we were restricted to enterprises in collaboration with Al-Elm via the provided technological services.

The starting point of our action case study was to examine EAM maturity in Saudi Arabia and to observe the various industries employing EAM frameworks. This is significant to comprehend the degree of EAM awareness in Saudi Arabia and which industries are progressing faster than others. Different sectors have a direct impact on how they value and understand the importance of EAM. In addition, it is important to facilitate the analysis of our identified challenges and their associations to their industry sectors.

4.1.3 Participating Stakeholders by their Roles

The ability to collect related feedback was ensured by questioning stakeholders working in EAM or associated areas. We ensured that we obtained information from stakeholders covering all areas associated with EAM. In addition, we tried to avoid participants with identical positions.

Table (4.3) shows the participating stakeholders categorized by their position title in Al-Elm. The main category in our study comprised EA architects (32%) followed by EA consultants (16%). EA consultants were invited at a later stage to complete the questionnaire regarding a particular client (Al-Elm) where the action case study took place. The remaining participating stakeholders involve upper management (12%) in addition to IT developers, technical personal, and project managers. Furthermore, we enquired about their own experience in EAM as well as the experience and progression of EAM in their enterprises.

TABLE 4.3: What are the roles of the participating stakeholders within their enterprises?

Post	Number of participants	Percentage
EA architects	18	32%
EA consultants	9	16%
Upper management stakeholders	7	12%
IT developers, technical personal, analysts, and project managers	23	40%
Total	67	100%

Most of the questioned stakeholders had experience in EAM of close to three years or less, and a limited number of participants had about ten years or more. Therefore, this demonstrated that the area of EAM is still a progressing immature area for enterprises; this supports claims in [Ahlemann et al. \(2012\)](#); [Buckl et al. \(2011c\)](#); and [Farwick et al. \(2012\)](#). While EAM is a young topic, it is even harder for enterprises in developing countries to find experts in the area, since there will be relatively fewer experts with lots of years of experience. The involved stakeholders have different expertise and degree of involvement, see Table (4.4).

TABLE 4.4: What are the participants' expertise and degree of involvement?

Background				
Numbers of years working with EAM framework	Nature of interaction with EA (scale Low 1 - 5 High)	Number of enterprises where you have experienced working with EAM framework	Familiarity with different EAM frameworks	Is there any customized solution built within the organization?
29% less than 3 years	9% scaled 1	31% listed 1 enterprise	43% named 1 framework	56% mention partial customization 1
41% Between 3 and 7 years	14% scaled 2	40% listed 2 enterprises	38% named 2 frameworks	30% None
15% Between 7 and 10 years	31% scaled 3	14% listed 3 enterprises	6% named 3 frameworks	6% Unaware of any customization
8% More than 10 years	26% scaled 4	7% listed 4 enterprises	7% had experience with customized solutions	8% Yes
7% less than 6 months	20% scaled 5	8% listed 5 or more enterprises	6% have theoretical awareness only	

There were a number of stakeholders who had no special knowledge of EAM frameworks but work with relevant departments from different areas. The enterprises created relevant EAM teams around 2010 and previously had a number of described and acknowledged EAM practices while they are not yet at the stage of development.

4.1.4 The EA Landscape Representation by EAM Function in Enterprises

An initial group of questions was designed to understand basic information about practices of EAM in enterprises; the outcomes of these enquiries illustrate the actuality of application landscape, models representation, and difficulties facing enterprises employing EAM frameworks. All outcomes were examined bearing in mind the literature views on EAM. A number of the outcomes obtained from this study require further research, and are beyond the scope of this research.

A common understanding of what EAM landscape should comprise is important, to grasp the purpose of our questions. Therefore, in the scope of our research we limit EAM information to all components and associations amongst the landscape with business applications and processes. The core of EAM efforts contains the present state of EA, develops several planned EA states, and produces alternative target EA states (Buckl et al. (2008); The Open Group (2009b); Wegmann (2002)). In general, it commences with the documentation of enterprises' flow of data to depict the present state of EA (Wegmann (2002)) in order to build the basis for the harmonization of future EA states.

Consequently, this group of questions was designed to grasp and categorize these enterprises in accordance with their present state of EAM progression. Table (4.5) shows the modelled states of EAM across different industry sectors. The enterprises varied across different governmental sectors including financial and technological sectors. The outcomes show distinctions in the modelled states of EAM; whereas no more than 40% of enterprises modelled a target EA state overall, most of the financial (61%) in addition to the technological (47%) modelled desired target EA state.

TABLE 4.5: To what degree do enterprises model their EA–EAM progression?

Industry sector	Existing EA	Target EA	Future EA
Governmental	85%	67%	21%
Financial	72%	61%	61%
Technological	80%	49%	47%
Overall	76%	61%	40%

4.1.5 The Main Difficulties Facing EAM

The literature of EAM describes enormous advantages gained from the employment of EAM frameworks in enterprises (Ahlemann et al. (2012); Buckl et al. (2011c); Farwick et al. (2012); Luna-Reyes and Andersen (2003); Sterman (2000); Wagter et al. (2005)). Nevertheless, the latest publications explain that the realization of these advantages only is ensured when the maturity of the EAM endeavours has reached a certain level ((Ahlemann et al., 2012; Lagerstrom et al., 2011; Weiss et al., 2013)). Enterprises face several difficulties on the path to reach this maturity of EAM endeavours; these difficulties have clear implications for the general apparent realization of EAM function (Kaisler et al. (2005); Lucke et al. (2010); Ross (2003)).

In order to contribute to the inclusive awareness of these difficulties, the following part of the business survey was designed to gather the most common difficulties facing these enterprises. A list of difficulties was extracted from the literature and offered to participating stakeholders. They were invited to choose the main difficulties facing their enterprises, while allowing them to choose from multiple choices. Furthermore, participating stakeholders were allowed to offer thorough explanations of the reasons for their choices and could include different difficulties apart from the offered ones. The outcomes from this group of questions are illustrated in Table (4.6).

The outcomes show that only a small minority of stakeholders have indicated no difficulties facing their enterprises (4%). This is a clear sign that the majority of enterprises struggle throughout the employment of EAM even with the existing strengths of EAM frameworks, as well as the growing knowledge and maturity of EA architects.

The outcomes show that the majority of participating stakeholders have stated that the most frequent difficulties are the endeavours of first gathering and updating business initiatives' goals, tasks, and attributes, in addition to, second, the sufficient quality of modelled states' representation. Business behaviour consists of business initiatives' goals, tasks, and attributes, in addition the the events triggering a change. The quality of the representation covers the inclusiveness, reliability, and actuality. These two difficulties were chosen both as the main difficulties facing EAM by 61% of the stakeholders. Our solution deals with these two difficulties.

TABLE 4.6: What are the main difficulties facing EAM?

Difficulty	Percentage
Endeavours of gathering and updating business initiatives' goals, tasks, and attributes	61%
Sufficient quality of modelled states' representation	61%
Unsatisfactory tool support	29%
Lack of upper management support	24%
Undervaluation of business initiatives' ROI	18%
Irrelevant references	7%
No specific challenge	4%

This result backs the significance of the problem addressed by our solution, in addition to the feedback from the conducted interviews with EA architects during our action case study. This is in line with the literature ([Lucke et al. \(2010\)](#)), which signified that manual EAM information gathering is a key concern in current enterprises.

Nevertheless, we have to point out that the action case study itself might have alerted stakeholders to the issue of business behaviour dynamism in EAM. This could have had an impact and led to a partiality that engaged stakeholders to the purpose of the study. To be exact, this might have encouraged stakeholders who faced difficulties with information gathering to take part in the questionnaire.

A lower number of stakeholders have selected unsatisfactory tool support as a key difficulty (29%), although, some literature has identified unsatisfactory tool support as a key

difficulty (Kaisler et al. (2005); Lucke et al. (2010); Ross (2003)). On the other hand, lately the development of EAM tools has improved the level of satisfaction (Matthes et al. (2008)). The outcomes indicate that 24% of the stakeholders chose the lack of upper management support as a main EAM difficulty, which is acknowledged also by the literature (Kaisler et al. (2005); Lucke et al. (2010)). The outcomes of our study point to variation of the nature of upper management support in relation to the industry sector. For instance, 12% of financial enterprises lack proper support and 61% of technological enterprises lack proper support, while 28% of the other sectors lack support.

These findings illustrate that approximately one out of three EAM initiatives lack management support, which is vital to grasp changes/dynamism in enterprises (Kaisler et al. (2005); Lucke et al. (2010)). A major motive for this practice is the management view on EAM initiatives, where they undervalue the initiatives' return on investment (ROI). The outcomes indicate that 18% of the stakeholders still chose the undervaluation of initiatives' ROI as a difficulty.

In addition, a number of stakeholders state the challenge associated with assessing ROI in their textual explanation. The supposed undervaluation of ROI is significant, where dynamism currently facing EA might lead to struggles to encourage stakeholders. Other difficulties were also stated, as improper integration of processes and tools, as well as presented documentation of architecture in enterprises. This offers an additional pointer that improved tool and guidance support would improve EAM practices.

4.1.6 The Gathering Approach of Business Initiatives' Goals, Tasks, and Attributes

Another group of questions were designed to understand how goals, tasks, and attributes of business initiatives are gathered within the enterprise. This is to understand the current means of gathering data rather than the nature of the process. In other words, illustrating the way the gathering of goals, tasks, and attributes of business initiatives is actually structured and completed, see Table (4.7). The outcomes of the questionnaire show that 62% of the respondents manually study and examine the presented documents and then extract the coherent goals, tasks, and attributes of business initiatives.

The outcomes of the questionnaire show that the other plans centred around communications among stakeholders within the enterprise are less frequent (20%). These communications involve meeting between stakeholders from different organizational units (53% of the remaining set), technological communication via models exchange 32%, and questionnaires 15%. The remaining 18% of respondents have indicated the use of some automatic mechanisms. This encourages our proposed guidelines for modelling the collective thinking of participating stakeholders.

TABLE 4.7: What are the gathering techniques of goals, tasks and attributes of business initiatives?

Approach	Percentage
They are gathered manually from documentation	62%
They are gathered manually including human interactions (such in meetings, enquiries, and workshops)	20%
They are incompletely gathered with the utilization of some automatic mechanism	18%

4.1.7 Maturity of EA Models Maintenance

Another group of questions were designed to understand the process of maintaining EA models updated during each initiative cycle. The outcome of this group of questions is considered a key finding of our study, see Table (4.8). Only 19% of the participating stakeholders declare that they follow some guidance explaining how to maintain and update data. The remaining 81% declared that no guidance or mechanism description is provided to maintain up-to-date EA models.

This finding shows that the utilized mechanism for EA models maintenance is still in an unplanned and improvised state. In the light of this finding, we argue that enterprises employing EAM frameworks should develop a mechanism for gathering and updating EA models, to be more effective with an unambiguously distinct mechanism clarifying the acts, triggers, and roles. This identified objective is facilitated by our solution.

TABLE 4.8: What are the development levels of EA models maintenance?

Maturity	Percentage
Guidance exist in enterprise	19%
Guidance does not exist in enterprise	81%

4.1.8 Change Generators

The only way to offer a new methodology dealing with dynamism is by confining this methodology to clear identification of possible change generators causing dynamic changes in business initiatives' goals, tasks, and attributes, i.e. business behaviour. Therefore, we have conducted practical observation of all common change generators/events, triggering these constant changes. In addition, we began with extracting and analysing these events before implementing the new methodology. This is significant to maintain representation of initiatives within EAM frameworks synchronized with the current state of reality.

Stakeholders working with EAM frameworks need to be conscious of events influencing their EA. Therefore, we designed a question to identify the triggering events causing changes which need to be updated during each initiative cycle. The results and analysis of the events triggering an update of EA models can be found in Table (4.9).

The survey reveals that the majority of manual updates are triggered by routine cyclic tests carried out with related stakeholders; 61% of stakeholders offer data on respective initiatives representation within EA. Additional events are the utilization of manual updates for the acquirement of new services (13%), installation of a new version of EAM frameworks tools (6%), initiative achievement (11%), and the execution of new mechanisms (7%). The ability to identify these common triggering events helped us to redesign our solution. The results in Table (4.9) were key to the classification of change-generators in our extended meta-model.

Excellent communication between respective stakeholders and architects managing EA is the key to successful representation of changing business behaviour. This shows the significant value of our proposed guidelines of joint understanding, see Chapter (6).

The lack of methodological communication is the main cause for delay of updates which will cause remarkable consequences for the desirable outcomes. The communication initiated by stakeholders in various enterprises units is not as much as communication initiated by EAM architects, which is in line with the difficulty of offering benefits for stakeholders holding information in an EAM framework ([Ahlemann et al. \(2012\)](#); [Lucke et al. \(2010\)](#)).

Other triggering events arise with low occurrence, such as substantial transformation of EA which occurs in events changing the enterprises' nature as in merging two different organizations. Additional triggering events arise with technical issues of the manual update itself, as in the ticketing method; technical reports have also suggested the consideration of such triggering events. A detailed description of a wide range of change generators can be found in [Ahlemann et al. \(2012\)](#); [Farwick et al. \(2012\)](#). We investigated the literature and considered the contextual factors affecting the environment surrounding our action case study in order to select the most common change generators. The terms used to designate these change generators were altered to avoid conflicts with existing terms of TOGAF. These technical reports additionally support the consideration of potential use of tools outside EAM frameworks, which may require manual update as tools of project management ([Ahlemann et al. \(2012\)](#); [Fuchs-Kittowski and Faust \(2008\)](#); [Matthes et al. \(2008\)](#)).

TABLE 4.9: Which change-generators/events within EAM function will cause changes in EA Models?

Event	Percentage
Routine periodic checks, such as quality assurance checks or area of responsibilities checks	61%
The utilization of manual model updates for the purpose of acquiring new services	11%
Enterprise architects triggering manual model updates for the purpose of acquiring new resources (such as, new devices)	11%
Initiative achievement	21%
Changes to the structure of the enterprise (such as: new assets or being sold)	2%
Installation of a new version of EAM frameworks tools	6%
Amendments at run-time to EA landscape coming from stakeholders gathering EA data manually	14%
The execution of new business mechanisms	7%
Update demands from stakeholders via internal mechanisms (such as: ticketing-assignments register)	3%
In the case of utilization of tools outside EAM environment, changes to these tools can generate changes	1%

4.1.9 Difficulties Specific to The Gathering of Goals, Tasks, and Attributes of New Business Initiatives

The answer to this question will provide important evidence as to the value of our proposed solution; it shows how the solution can enable enterprises to avoid huge efforts to overcome a number of difficulties. Most enterprises state redundant efforts of data gathering and poor representation of EAM initiatives and models as their main difficulties faced in manual management of EA frequent changes. In addition, the outcome shows particular difficulties of data gathering associated with manual management of dynamism. This is important evidence in support of the goals of our proposed solution.

The extracted and analysed data from the business survey was categorized into a number of major difficulties facing the data gathering and representation of EAM, see Table (4.10). The vast majority of enterprises identify the major challenge of data gathering as being the time taken (71%). Addressing the time-consuming issue is a contribution and a motivation for this research; this outcome is in line with results in Fowler (2008) and Maynard and Gilson (2014) as it highlights the time-consuming nature of this challenge.

Some 30% of stakeholders have highlighted the difficulty of gathering as an act as a different challenge where they clarify the difficulty of the acquisition of data itself, the challenge being in harmony with the previous one. A number of enterprises mentioned the difficulty of the topicality of the presented EA models (7%). When asked about how satisfactory the quality of the models was, 39% have noted unsatisfactory. This supports the purpose of our proposed techniques, see Chapter (6). Others (21%) have contradicted the previous group and stated that their EAM models are in line with required updates in a reasonable time. A small minority of enterprises claimed that they don't face particular difficulties (3%).

TABLE 4.10: What are the implications of handling dynamism manually?

Implication	Percentage
It is time-consuming	71%
The difficulty of the acquisition of data, including unavailability of data	30%
The actuality of the presented EA models	7%
Inability of enquiring information from designated stakeholders	8%
Unsatisfactory quality of EA models	39%
The challenge to have EA models in line with run-time changes within time limits	21%
Irrelevant references	7%
Contradictions between EA models	7%
No difficulty	3%

4.1.10 Group Formation of EAM Function

The answer to this question will provide valuable indications to how the solution should be developed; it shows how our solution should adapt to different ways of handling this problem in different enterprises. It also clarifies aspects of how our solution should be achieved by being aware of how teams are organized to deal with this problem. The answers to this question were divided across three alternative organizations: central, federated, or both, see Table (4.11).

Accordingly, 52% of participants stated that the group responsible for representing business behaviour within their enterprise is organized centrally. They gathered data from several documents and stakeholders in different enterprise units. On the other hand, 39% of participants stated that the group responsible for representing business behaviour within their enterprise has been organized in cooperation between central and federated groups. This occurs with federated groups across a number of enterprise units on the one hand and a central group on the other.

The rest of the surveyed stakeholders (9%) have clarified that business behaviour have been represented manually from stakeholders in several of the enterprise's units without a clear sense of organization. All surveyed stakeholders have noted that huge effort is required to accomplish the task of communicating and agreeing on business behaviour representation regardless of the group organization. This point is an important indication of the value of a possible contribution minimizing these efforts. This variation supports the importance of collective thinking across participating stakeholders, our proposed guidelines and new constituents can be found in Chapter (6).

TABLE 4.11: How enterprises' stakeholders communicate to change the representation of business behaviour?

Formation	Percentage
The group has been organized centrally	52%
The group has been organized federally	4%
Cooperation between central and federated groups	35%
Without a clear sense of organization	9%

4.1.11 Automated Gathering of Changing Sources of Information

The outcomes showed that 14% of the participated stakeholders attempted to utilize some kind of automation when changes in business behaviour has caused an update in EA models. The rest of the surveyed stakeholders indicated that updating changes had been gathered manually from stakeholders in several enterprises' units. The participants who employed some kind of automation have identified these methods as mainly file import methods; detailed naming of these methods can be found in Table (4.12). These results back claims of [Matthes et al. \(2008\)](#) that the majority of EAM frameworks merely maintain the utilization of general methods offering support to infrequent tasks, methods such as Excel or XML.

TABLE 4.12: Are there any attempts to develop or utilize automated solutions, rather than manual, across enterprises to update EA models?

Utilization of automation	Percentage
None	80%
Some kind of utilization: Excel, XML, CSV, relational database import, or SOAP and REST web service interface	14%
Cannot be identified	6%

Summary of the Business Survey Chapter with Guidance to the Remaining Chapters

This chapter presented the outcomes from the business survey we conducted in Saudi Arabia to examine EAM practices regarding our areas of concern, see Section (4.1). It offered an examination of the current state of EAM practices in Saudi Arabia. This supported our gradual development of the proposed solution by studying the contextual factors surrounding EAM practices in relation to changing business behaviour.

The following Chapter (5) outlines the activities we carried out to interact with the problem context inside Al-Elm. In addition, we identified the requirements that have guided the development of our proposed methodology and extended meta-model. Chapter (6) describes the proposed methodology extending on the practices of the architectural development method (ADM) of the open group architecture framework (TOGAF). Chapter (7) offers a critical reflection on our action research involving solution's employment, limitations, discussion points, and analysis associated with the use of action research as our research methodology. Chapter (8) summarizes the learned lessons and future research points.

Chapter 5

The Action Research Case Study

This chapter illustrates the endeavours we carried out to continuously develop, redefine, and improve our solution during the early stage of our action case study. We first describe how we interacted with the problem context inside Al-Elm, see Section (5.1). We then identify the challenges for proposing new constituents to our extended meta-model and the available methods and tools that we used to address these challenges, see Section (5.2). Afterwards, we summarize the identified requirements that have guided the development of our proposed methodology and extended meta-model, see Section (5.3).

5.1 Consideration of the Enterprise Context

This section discusses the early tasks of our action case study aiming to validate our solution's design. It discusses some of the stakeholders early remarks about our solution development. This is helpful to consider a number of possible approaches and how to interact with the problem context.

There was a scheduled training for us to understand the employed enterprise architecture management (EAM) processes within the enterprise. After that, we were assigned to an enterprise architecture (EA) team with a leader who was responsible for our action case study; this individual was in direct collaboration with the research and development unit (RDU) at Al-Elm. There were a number of scheduled activities assigned to participants to ensure the awareness of our research and acceptance of team members.

In addition, there were a number of presentations in the early period of our presence in Al-Elm; these were intended to raise the sense of involvement and to receive early feedback that could improve the quality of our action case study.

After that, a certain period was allocated to understand in depth the current practices in order to realize the differences in practice from theory. This was significant for evaluating the proposed requirements of the solution. A thorough observation and learning period was initiated to grasp existing techniques and how they differ from standard practices and what is specific to the organization and the region. There was customization of the EAM practices. A number of other preparatory tasks were mentioned in the methodology chapter, see Chapter (3).

After all the preparatory tasks, there was a concise introduction to the solution, where key notions of the methodology were clarified, and all stakeholders participating in our case were invited to utilize the initial model to implement the parts of the clarified solution. Most of the participants were highly involved in the process, while others participated by correspondence with their respective roles within the enterprise and were observing the process. One of the phases of the action case study was the questionnaire.

There were many alternative proposals to address the research problem at the earlier stages of our action research. An example of earlier attempts is the work we published on the use KAOS ([Lamsweerde \(2003\)](#); [Matulevičius et al. \(2007\)](#)) for requirements analysis, see our earlier proposal in ([Almisned and Keppens \(2012\)](#)).

The resulting observations from the business survey, which were presented in the previous Chapter (4), facilitate redesigning the proposed solution with the aim of reaching the best approach to addressing the research objective.

The employment of EAM frameworks is generally faced with the lack of prescribed steps in applying some of the rigid capabilities of the frameworks in practice. Consequently numerous enterprises face difficulties applying some of these capabilities with a lack of a governing method for their initiatives ([Ahlemann et al. \(2012\)](#); [Buckl et al. \(2011c\)](#); [Farwick et al. \(2012\)](#); [Wagter et al. \(2005\)](#)).

However, the desirable EAM processes offered by the frameworks are hard to resist and cannot be achieved by other sources, such as the traditional workflow management ([Ahlemann et al. \(2012\)](#)). On the other hand, these other sources offer beneficial features that are not technically fitting to assist EAM processes. Therefore, our solution parts have

attempted to utilize these features in existing approaches and integrate them into EAM practices.

We have employed our proposed solution during the action case study to reflect and examine its validity. The implementation of this solution was part of our action case study for evaluating its ability to offer enterprises a solution that addresses changing business behaviour.

Our initial model of the solution was evaluated throughout the action case study comprising interviews with stakeholders who were part of that implementation in their enterprise; all stakeholders have some knowledge of EAM. We proposed a solution with the aim of addressing identified challenges and attempting to fulfil the research objective. The stakeholders' assessment was debated in line with the literature and the resulting outcomes.

5.2 Challenges for Extending the Meta-Model and The Used Tools

In this section, we first describe the abstract challenges that faced our proposed extended meta-model, see Subsection (5.2.1). Afterwards, we present the offered methods and tools that we utilized to address these challenges, supplemented with alternative methods and tools that can be employed, see Subsection (5.2.2).

5.2.1 Challenges Governing the Proposed Constituents

The following challenge was concerned with revising, comparing, and investigating EAM frameworks to find a practical and feasible way to contribute to the ability of the frameworks to handle dynamism in enterprises.

- To find concepts that are easy to use, because the complication of notations will result in concepts that will probably not be utilized in practice. The purposes of these concepts are preferred to have been experimented with before and proved to be practical and useful, rather than suggesting concepts from scratch.

- The first challenge might entail us searching for concepts in existing languages and gathering verified ones from different languages to meet our modelling requirements. However, it raised the possibility of complex appliance of the resultant language due to difficulty understanding the intended purposes by architects in reality.

The following challenges were associated with the applicability of the produced meta-model:

- The integration of the extended meta-model into EAM frameworks. Therefore, the ability to find recognized means to establish this treatment in the field was a key challenge. This entailed the need to bridge the development with existing EAM frameworks. Another challenge was finding and organizing a proper way to investigate the proposed treatment in reality with an employed EAM framework.
- Realization of the implication of changing business behaviour on high-level goals. EAM frameworks have asserted that adapting and coping with change is a significant necessity. With the intention of supporting the analysis of the influence of change, EAM frameworks aim to trace and identify associations between high-level goals on one side and business behaviour/ practices between parts of the EA on the other side. The ability to measure the level of achievement is crucial.

We utilized the a number of guidelines to decide on aspects of development rather than using them as hard criteria with identified rules that would be validated later. First, a requirement for our development was keeping the development small and simple. Second, we attempted to make the proposed treatment extensible. Third, another guidance was to attempt to assist documentation, communication, and reasoning regarding requirements. First, the requirement to keep the development small and simple was approached by building on a group of standard constituents from already existing approaches, which permitted architects to represent the intended aspects of EA using familiar terminology. This was significant in attaining an extension to Archimate ([The Open Group \(2009a\)](#)) that facilitates ease of comprehension and employment.

Second, our solution was designed with the capability of expansion with particular constituents and their related examination. This was approached by deciding to extend on the current practices of the architectural development method (ADM) of the open group architecture framework (TOGAF) ([The Open Group \(2009b\)](#)), which is highly supported by continuous development. This permits architects to choose from fundamental and composed adaptations of our solution. Third, Another guidance is to attempt to assist documentation, communication, and reasoning regarding requirements. This was addressed by

offering guidelines for the modelling of shared understanding of business behaviour with agreement from different involved stakeholders.

5.2.2 Tools to design our Extended Meta-Model

This subsection presents the tools for defining an extended meta-model to enable further representation capacity of EAM as well as addressing language applicability, as we were not planning to introduce a new language from scratch.

- In order to integrate our produced language with EAM frameworks, we aimed to align our meta-model to an **EA modelling-language** named **ArchiMate** ([The Open Group \(2009a\)](#)). We used ArchiMate as the base language on top of which our approach was defined. ArchiMate is a standard of [The Open Group \(2009a\)](#). This is key to allowing our development to be integrated with EAM frameworks, and mainly TOGAF. In addition, doing this has the advantage that architects have previously utilized it in practice. It is an open and self-sufficient modelling language intended for EA. It is supported by diverse tool vendor and consulting groups.
- The proposed notation extends ArchiMate 1.0 ([The Open Group \(2009a\)](#)) with a tool-aid in the shape of an editor. This editor facilitates the construction of integrating EA information models as well as goal-oriented models. Any modelling language, especially those used in practice, will only achieve its goals if it is supported by specialized tools. We needed a model editor to ensure that our models would be used properly and consistently. Therefore we used the architecture modelling tool **BiZZdesign Architect** as an add-on to ArchiMate ([BiZZdesign](#)). It provided facilities that are specialized for an EA modelling language; it is based partially on ArchiMate. It also supports the use of viewpoints. Analysis of models is difficult to do manually and also needs tools. We implemented several helpful techniques in BiZZdesign, such as evaluation of alternatives and detection of conflicting interests and solutions. **BiZZdesigner** is a well-supported tool that could be utilized for the desired purposes (BiZZdesigner was previously known as Testbed Studio).
- **ArchiMate workbench** is offered by ArchiMate project as an EA tool that is a well-integrated group of EA tools that address different integration aspects: data,

control, and presentation integration ([The Open Group \(2009a\)](#)). ArchiMate modelling language can be used to integrate models expressed in heterogeneous modelling languages.

- The new constituents of the extended meta-model were modelled/instantiated with the help of an EAM tool, using a number of means/syntax, such as Unified Modelling Language (UML) class-diagrams or others. The used tool in our action case study is TOGAF 9 method plug-in for the open source eclipse process framework composer tool ([The Open Group \(2009b\)](#)). In practice, the tool was used to carry out specific tasks via its form-based flow. An instance of such tasks is responsibilities allocation or constraints identification.
- The complete integration between a specific modelling language and the workbench will require a bottom-up and a top-down **transformation** between the specific language and the ArchiMate language. In order to decrease the potential abstraction variance, ArchiMate constructs might be signified with 'is-a' relations. For instance, application component in ArchiMate could be dedicated to UML application construct, bearing in mind this could add attributes or give precise semantics to the concept.
- In the field of EAM, especially for developments on top of TOGAF, developments will only be established if they are experimented with in a real enterprise. Using small test case studies will not make a development considered valuable and properly evaluated to any level. Therefore, this validation was in coherence with **Technical Action Research (TAR)** ([Fals Borda et al. \(1991\)](#)), wherein an artefact is validated essentially by means of using it to treat a real-world problem, see Subsection (3.1.1). The iteration over the TAR structure enabled us to overcome the challenges of difficulty, misuse, or complexity of the utilized notations.

5.2.2.1 Alternative Methods

There are several methods and tools that aim to maintain requirements modelling, such as System Architect and Powerdesigner, although, this is usually restricted to documenting

requirements as use-cases or structured lists. Typically, neither graphical modelling techniques nor modelling integration is provided. We name a number of alternative tools and methods in the following list:

- One of the methods that we considered at the early stages of this study was reusing and merging concepts from recognized **Goal-Oriented Requirements Engineering (GORE)** languages ([Van Lamsweerde \(2001\)](#)). The idea was to employ these concepts to materialize bidirectional traceability. There are a number of techniques for goal modelling that we could utilize and extract concepts from, such as the Business Motivation Model ([Dardenne et al. \(1993\)](#)), the i* framework ([Moody et al. \(2009\)](#)), and the KAOS notation from [Matulevičius et al. \(2007\)](#) and [Lamsweerde \(2003\)](#). At the earlier stages of our action research, we have published a paper on the use KAOS ([Almisned and Keppens \(2012\)](#)).
- Another potential tool is EnterpriseArchitect ([Sparks \(2000\)](#)); whose representation is based on UML. For motivation purposes, this tool also relies on goal modelling techniques up to a certain level. However, it does not utilize GORE concepts ([Van Lamsweerde \(2001\)](#)).
- Another method is Dynamic Essential Modelling of Organisation ([Dietz \(2001\)](#)). This concentrates on specifying important models of an enterprise, and is increasingly widely recognized.
- Another possible method is Rochade, which is built on a wide-ranging language ([Allen Systems Group](#)). In addition, it is well-supported in the literature.

5.3 Guidance for the Redefinition of the New Constituents and Techniques

This section offers a description of the identified requirements that have guided the development of our proposed methodology and extended meta-model. The continuous refinement of our new constituents were driven by adherence to these requirements. They offer guidance for any proposed method addressing areas of concern participating in EAM endeavours to cope with dynamism. They were a result of the earlier stages of our action research. There were extracted from literature investigation and the examination of the documentation of the actual practices within the studied enterprise. However, it has to be considered that undocumented practices that were reserved in the minds of stakeholders were gathered via interviews that were conducted within the enterprise where the case study took place.

While these requirements were extracted to guide the design of our solution, they also offer guidance for wider opportunities for development exceeding the scope of our research. The fulfilment of these requirements vary from partial, complete and unfulfilled, Chapter (7) discusses the stakeholders' assessment of their fulfilment. They can be utilized for future development, see Tables (5.1, 5.2, 5.3, 5.4, 5.5). An EAM method refers to the set of practices driving EAM in an enterprise, i.e. such as the architecture development method (ADM) of TOGAF, see Chapter (2).

TABLE 5.1: The desired requirements of an improved EAM method – Part 1

Business Behaviour management Part 1		
Feature	Explanation	Relevant literature
A1 Clear and managed responsibilities	Issue: Every participating stakeholder should be able to view all responsibilities and roles associated with an initiative they interact with. The significance of this feature is noticeable for the ease of collaboration. Means: Extended meta-model.	(Herrmann and Kurz (2011); Kurz (2013); Swenson (2010))
A2 Developing initiatives and patterns	Issue: This feature concerns the nonstop joint progress for current and potential initiatives. Means: Extending ADM of TOGAF to involve chosen best practices that are generalized in a form feasible to be used by architects. Guidelines that already exist in the mental model of architects need to be formed in a way that supports shared understanding.	(Herrmann and Kurz (2011); Motahari-Nezhad and Bartolini (2011); Schonenberg et al. (2008); Swenson (2010))
A3 Flexibility throughout execution	Issue: Throughout the cycle of an initiative, the roles and responsibilities should not be mandatory to offer flexibility throughout the implementation. Therefore, a skip and redo role must be contained in the task, in addition to the execution roles. This is contrary to usual workflow management. Means: Extended meta-model.	(Herrmann and Kurz (2011); Kurz (2013); Swenson (2010); Van der Aalst et al. (2003))
A4 Visibility of initiative progression	Issue: Stakeholders should be capable of realizing the progress of an initiative, where completed tasks are acknowledged and the remaining ones are identified. Means: Introduction of our proposed methodology.	(Herrmann and Kurz (2011); Swenson (2010))
A5 Observable development of tasks	Issue: The visibility of open tasks and their challenges is key to the realization of an initiative. Means: Extended meta-model.	(Herrmann and Kurz (2011); Swenson (2010))
A6 Transparency and visibility of initiative goals	Issue: The goals of initiatives have to be declared and communicated to state the expected final outcome from an initiative, although the mechanism stages and actions can be unidentified and unpredictable because the goals will be more constant. Means: Extended meta-model.	(Herrmann and Kurz (2011); Kurz (2013); Swenson (2010); Tran et al. (2013))
A7 Hierarchical structure of activities	Issue: Hierarchical structuring of tasks in contrast to process networks enables architects to easily include additional tasks. This suggests the identification of tasks in advance followed by incremental improvement. Means: Introduction of structured techniques relying on an extended meta-model with minimal new meta-classes.	(Herrmann and Kurz (2011); Swenson (2010))

TABLE 5.2: The desired requirements of an improved EAM method – Part 2

Business Behaviour management Part 2		
Feature	Explanation	Relevant literature
A8 Clear and simple assignment of responsibilities and roles	Issue: There is a need for a mechanism on an abstract level that enables new stakeholders to be assigned to an initiative with their associated responsibilities. Means: Introduction of our proposed methodology.	(Swenson (2010); Van der Aalst et al. (2003))
A9 Integration of attributes to the initiative	Issue: Data must be the main driver for the development of an initiative. While data and process are closely incorporated as a result of the document-centric nature, this is different from customary activity-centric workflow management. Means: Extended meta-model.	(Herrmann and Kurz (2011); Kurz (2013); Swenson (2010); Van der Aalst et al. (2003))
A10 Identification of rational dependencies across activities	Issue: The modelling capability must facilitate the definition of dependencies between tasks to be implemented at a certain time in contrast to dependencies that are not relative to what time they are implemented. A number of tasks can have pre-conditions that need to be accomplished prior to their implementation. Means: Extended meta-model.	(Kurz (2013); Swenson (2010))
A11 Comprehensible and flexible for business stakeholders	Issue: The representation of initiatives should be fully understood by high-level management stakeholders with no EAM or modelling knowledge. In addition, they have to be able to resolve and plan future tasks of initiatives. Means: Introduction of structured techniques relying on an extended meta-model with minimal new meta-classes.	(Kurz (2013); Swenson (2010))
A12 Flexibility of enabling new roles and stakeholder at run-time	Issue: Architects responsible for the execution of a particular initiative should be able to assign additional stakeholders to the initiative if required at run-time. Means: Extended meta-model.	(Herrmann and Kurz (2011); Kurz (2013))
A13 Identification of temporary and pre conditions	Issue: Meta-classes of EAM must enclose attributes representing tasks' pre-conditions that need to be accomplished prior to the implementation of the tasks. Means: Extended meta-model.	(Kurz (2013); Swenson (2010))
A14 Availability of guidelines	Issue: Guidelines previously exist in the mental model of architects. They need to be formed in a way that supports shared understanding of business behaviour between involved stakeholders. Means: Introduction of guidelines for modelling a shared understanding.	(Motahari-Nezhad and Bartolini (2011); Schonenberg et al. (2008))

TABLE 5.3: The desired requirements of an improved EAM method – Part 3

Key required outcomes from any improvement of EAM practices in relation to maintenance of EA models		
Feature	Explanation	Relevant literature
A1 Counter attributes identification	Issue: Throughout the data representation process, stakeholders appear to face lack of counter attributes identification. The fulfilment of this concern can add value to the process completion. Means: Extended meta-model.	(Buckl et al. (2010b); GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert (2005); Matulevičius and Heymans (2007); Moody et al. (2009); Plazaola et al. (2008))
A2 Instant update to models' representation	Issue: Time constraints seems to be a challenge to modifications of models' representation. The ability to cope with this challenge can improve the dynamics of the process. Means: Introduction of techniques enabling constant maintenance of EA models relying on an extended meta-model.	(Frank (2002); Jonkers et al. (2005); Spinellis (2001))
A3 Additional endeavours for the selection process and analysis activities	Issue: During the initiative's life cycle, it appears that additional practices are usually employed to the selection process and analysis activities. The need for further endeavours apart from the existing ones is a concern. Means: Introduction of our proposed methodology.	(Frank (2002); Matulevičius and Heymans (2007); Moody et al. (2009); Spinellis (2001))
A4 Constant harmony with input from stakeholders	Issue: Current practices concerning the update of models' representation is an area of continuing development. Their ability to perform the update process at run-time in parallel with changes coming from different stakeholders is in question. Means: Introduction of our proposed methodology.	(Buckl et al. (2010b); Frank (2002); Plazaola et al. (2008); Spinellis (2001))
A5 Successful business requirements analysis	Issue: The alignment between mechanisms that are considered pivotal to a successful business requirements analysis and their incorporation to EAM need improvement. Means: Introduction of techniques enabling constant maintenance of EA models relying on an extended meta-model.	(Buckl et al. (2010b); GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert (2005); Jonkers et al. (2005); Plazaola et al. (2008))
A6 Inclusive representation of data associated to the initiative attributes	Issue: Stakeholders should be able to represent all utilized data that is associated with initiatives' attributes. The representation on the basis of the success of a single initiative with disregard to future initiatives conflicts with the purpose of EAM. Means: Introduction of techniques enabling constant maintenance of EA models relying on an extended meta-model.	(Buckl et al. (2010b); Frank (2002); Matulevičius and Heymans (2007); Moody et al. (2009); Plazaola et al. (2008); Spinellis (2001))

TABLE 5.4: The desired requirements of an improved EAM method – Part 4

Key required outcomes from any improvement of EAM practices in relation to modelling of shared stakeholders' understanding		
Feature	Explanation	Relevant literature
A7 Sufficient communication with associated stakeholders	Issue: It is important to examine how satisfactory is the communication with stakeholders in charge of making decisions regarding new initiatives. Means: Introduction of techniques enabling constant maintenance of EA models.	(Buckl et al. (2010b)); Frank (2002); GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert (2005); Spinellis (2001))
A8 Elimination of redundant endeavours	Issue: Several solutions can be partially implemented to address similar sub-requirements. The elimination of such redundancy is significant. Means: Introduction of techniques enabling constant maintenance of EA models relying on an extended meta-model.	(Frank (2002); Jonkers et al. (2005); Matulevičius and Heymans (2007); Moody et al. (2009))
A9 Shared mental model	Issue: The mental models that exist in various stakeholders' minds and experience can be very important to the success of any initiative. The ability to share and offer them in the form of guidelines is pivotal. We need to examine if the existing practices that are utilized for EAM function are affected by the lack of guidelines. Means: Introduction of guidelines for modelling a shared understanding.	(Buckl et al. (2010b)); Frank (2002); Plazaola et al. (2008))
A10 Actuality of representation from stakeholders' perspective	Issue: Various stakeholders highlight the need for further attributes to be included in the meta-classes, which are intended for initiatives' representation. The crucial issue is to analyse if the inclusion of such attributes is a necessity for improved EAM functionality. Means: Refinement of model's representation by offering further capacity of an extended meta-model.	(Frank (2002); GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert (2005); Jonkers et al. (2005); Matulevičius and Heymans (2007); Spinellis (2001))
A11 Structured data gathering	Issue: We should consider if the utilized mechanisms are time-consuming in relation to the data gathering aspect for initiatives' representation. Another point of concern is the value of structured techniques in comparison to manual guidelines. Means: Introduction of techniques enabling constant maintenance of EA models.	(Buckl et al. (2010b)); Frank (2002); GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert (2005); Plazaola et al. (2008))
A12 Harmony among different utilized solutions	Issue: We should first ensure that all employed mechanisms are in harmony with the current practices of EAM. The group of examined mechanisms should be within the scope of our research. Then, we should ensure that our solution is in harmony with the remaining mechanisms. Means: Introduction of techniques enabling constant maintenance of EA models.	(Buckl et al. (2010b)); Frank (2002); GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert (2005); Jonkers et al. (2005); Matulevičius and Heymans (2007))

TABLE 5.5: The desired requirements of an improved EAM method – Part 5

Key required outcomes from any improvement of EAM practices in relation to time-knowledge representation		
Feature	Explanation	Relevant literature
A13 Business stakeholders' adaptation at run-time	Issue: High-level management stakeholders have to be able to make decisions on future tasks of initiatives by means of comprehensive representation and mechanism of initiatives. Means: Introduction of techniques enabling constant maintenance of EA models.	(Kurz (2013); Swenson (2010))
A14 Same set of EAM knowledge	Issue: Throughout the development of our solution, we ensured that the participating stakeholders require no new knowledge in order to implement initiative endeavours within EAM function. Otherwise, the solution will face challenges in practice if an additional set of knowledge is required. This will offer simplicity and ease of integration. Means: Searching and expanding within the scope of EAM terminology and analogy.	(Buckl et al. (2010b); Frank (2002); GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert (2005); Jonkers et al. (2005))
A15 The capacity of underlying language	Issue: The focus here is on meta-modelling capabilities considered sufficient to fully represent the business requirements part of EAM. The capacity of underlying language should be studied and analysed. Then, proper extension to the meta-models should be offered. Means: Introduction of structured techniques relying on an extended meta-model.	(Buckl et al. (2010b); Frank (2002); GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert (2005); Moody et al. (2009); Spinellis (2001))
A16 Satisfactory and dynamic representation of high-level goals	Issue: We put forward the employment of system dynamics to add to current methods, see Chapter (6). These guidelines facilitate modelling stakeholders' behaviour and their decision implications. This modelling composes embedded application landscape progression principles that do not exist in formal guidelines but in the minds of diverse stakeholders. In order to achieve this, we extract a few guidelines from the literature for collective modeling of agreed on understanding of business behaviour. Means: Introduction of structured techniques relying on an extended meta-model.	(Buckl et al. (2010b); Frank (2002); GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert (2005); Jonkers et al. (2005); Plazaola et al. (2008))
A17 Management of triggering events	Issue: We first studied whether the offered mechanism to manage change triggering events is satisfactory. This was followed by the identification of these events. Afterwards, the representation of these events is improved. The implication of these events on structured maintenance aspects is considered too. Means: Introduction of structured techniques relying on an extended meta-model.	(Buckl et al. (2010b); Frank (2002); GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert (2005); Jonkers et al. (2005))

Summary of the Action Research Case Study Chapter with Guidance to the Remaining Chapters

This chapter explained the endeavours to continuously develop and improve our solution. We first presented the early interaction with the problem context inside Al-Elm, see Section (5.1). We then presented the used methods and tools to address the challenges we faced during proposing our extended meta-model, see Section (5.2). Afterwards, we summarized the identified requirements that have guided the development of our proposed methodology and extended meta-model, see Section (5.3).

The following Chapter (6) describes the proposed methodology extending on the practices of the architectural development method (ADM) of the open group architecture framework (TOGAF). Afterwards, we present in Chapter (7) an analysis of the outcomes from the structured interviews and questionnaire in regard to our solution. In addition, we offer a critical reflection on our action research involving limitations, discussion points, and conflicts associated with the used research methodology. Chapter (8) outlines the achievement of our research questions.

Chapter 6

The EAM Framework

In this chapter, we propose a methodology extending on the practices of the architectural development method (ADM) of the open group architecture framework (TOGAF) ([The Open Group \(2009b\)](#)). It aims to deal with dynamism by means of extending enterprise architecture management (EAM) underlying meta-model and offering techniques guiding EAM practices to face concerns related to the constant change surrounding enterprises. This methodology builds on a collection of techniques methodologically selected from well-established approaches and assembled with careful alliance to EAM frameworks.

We start by showing how our research questions have guided the development of our solution, see Section (6.1). Afterwards, we identify the main constituents and practices we used in our solution that our extended meta-model will build on top of them, see Section (6.2). Then, we describe our extended meta-model that enables the representation of our proposed techniques in order to facilitate the representation of multiple states of the enterprise architecture (EA) landscape in line with constant change, see Section (6.3). We then highlight the significance of a joint understanding of business behaviour among diverse stakeholders, see Section (6.4). In addition, we elicit and propose a number of driving guidelines for an improved modelling design of EA. After that, we propose a number of techniques to compliment the architectural development method (ADM) of TOGAF, see Section (6.5).

6.1 Answering Research Questions

This section signifies how our research questions, which were identified in the introduction Chapter in Section (1.3), have guided the development of our solution. We identify the points of emphasis for each question and the abstract approaches for addressing them.

- Research Question: Can an adapted or extended EAM framework be developed to deal with the dynamic business behaviour of an enterprise?
1. By what means can we ideally support the constant stakeholders' need for information that is governed by the particular business behaviour/context of their enterprise? see Sections (6.3, 6.5) and Figure (6.3). **Points of emphasis:**
 - Establishing techniques facilitating data maintenance of EA in order to minimize manual practices preliminary to modelling
 - Enabling the generation of change at timely events in order to enhance the actuality of EA landscape
 - Enhancing the correctness of the EA landscape representation via structured assessment of the models
 2. By what means can we ideally enable building EAM models reflecting constant change in business behaviour and goals, and consequently improving the planning of target EA states? see Section (6.3) and Figure (6.4). **Points of emphasis:**
 - The planning of a target EA landscape is arranged for a specified time in advance
 - EA models representing parts of EA are built at an exact time
 - An architect/stakeholder must realize that alternative representations of the target states are possible
 - An EAM meta-model must enable the representation of time dependencies of its model parts
 3. By what means can we ideally produce an EA landscape reflecting the different mental models of stakeholders? see Section (6.4). **Points of emphasis:**
 - The ability to support architects/stakeholders with a way to ensure collective understanding of business behaviour
 - The elicitation of guidelines to enable joint thinking, and modelling of business behaviour; in order to be collectively aware of the implications of such information

- Testing the applicability of these guidelines and reflecting on them

Abstract approaches:

- Assigning an indication to tasks for timely change generators that are linked to the corresponding stakeholders liable for a particular division of EA landscape; we call it **TimelyIT**
- Data gathering that supports automation with assessment of the models; we call it **AutoGA**
- Utilization of other information systems to identify timely change generators that are independent of EAM that prompt manual update of EA; we call it **independentCG**
- Utilization of internal timely change generators that are part of EAM that prompt manual update of EA models; an example of these events is the retirement time of an initiative; we call it **innerCG**
- The elicitation of simple and concrete aspects enabling an improved capacity of the underlying meta-model
- The utilization of current practices of sequential patterns' modelling
- Proposing a number of constituents as an extension to the meta-model
- Ensuring the simplicity, usability and familiarity of these constituents
- Proposing techniques enabling a responsive representation of EA states progression, in regards to constant changes and improved planning. This method will drive the utilization of the meta-model and its new constituents
- While EAM practitioners do not model their unspoken-of business behaviour owing to the lack of a clear employment technique, we will benefit from a number of practice-proven principles to extract and offer guidelines driving the modelling of target EA models with consideration of business changing behaviour, as a starting point.

6.2 Utilized Practices and Constituents

This section describes in brief the minimum set of constituents that we need in our solution. Our extended meta-model will build on top of these core constituents, see Section (6.3). We will identify the practices employing these constituents in subsections (6.2.1) and (6.2.2). Afterwards, Section (6.2.3) discusses the theoretical relation between efficient data maintenance of EA models and changing business behaviour.

These constituents are gathered from practices across different EAM frameworks, so they need to be presented in isolation from each other, because some frameworks merge a few of them into one meta-class with different names and comparable employment. The associations among these constituents are selected and presented in the proposed meta-model, see Figure (6.1). Ignorance of any of them will have an impact on the planning of future EA states. The following constituents are commonly symbolized as classes in the meta-models of different EAM frameworks; namely **processPart**, **EAMInfrastructure**, **modelPartRole**, **Element**, **Initiative**, **processApproved**, and **approveAssociation**. We highlight their use to avoid any confusion with different constituents of different EAM frameworks that might overlap with them in terms of their names or employment. These constituents are described next to clarify their employment:

- **ProcessPart T1** represents a cycle of associated reasonable, distinct functions. It should not represent an isolated stage of the function as that would make it hard to achieve a responsive EAM function; for instance it is a common practice in TOGAF. **ProcessPart** is associated with a number of **Elements** of the EA landscape, while it is supported by **EAMInfrastructure**. Within the management of an EA landscape, **processParts** are static as they are not influenced by changes generated by initiatives.
- **EAMInfrastructure T2** signifies a real exploitation of a tool/system on a specific site. Therefore, **EAMInfrastructure** reserves data indicating location and type. It also has an association to **processParts**: they maintain distinct **Elements**. To be represented in the EA landscape, a system has to be associated with/support to at least one **processPart**. It can signify a stage of **Initiative** before transformation.
- **modelPartRole T3** is part of the management of the EA landscape. It signifies the support by a **processPart** to a particular **Element** of the landscape. The particulars of the support are usually offered by **EAMInfrastructure**. It differs from **EAMInfrastructure** as it is not influenced by **Initiatives**, while both comprise **periodOfExpiration** stating the start of support and its end.

- An **Element T4** signifies a sector of the enterprise in line with its inner organization. An **Element** is an entity of the architectural description inside the enterprise, such as a unit or a geographical site. Within the management of EA landscape, **Elements** are static as they are not influenced by changes generated by **Initiatives**.
- **Initiative T5** is the key constituent directing transformations of EA. Thus, transformation of EA is a consequence of an achievement of an **Initiative**. This is the key constituent of EA comprising time-related attributes. As **Initiatives** are planned actions, time needs to be maintained to indicate start/end dates, as well as creation/removal time. This constitutes the **periodOfExpiration** allocated to all **Initiatives**. Within the management of EA landscape, **Initiatives** are dynamic as they are influencing and influenced by changes. **Initiatives** usually transform **EAMInfrastructure** and **modelPartRole**.
- **processApproval T6** signifies the approval/backing of a particular **processPart** by a particular **modelPartRole** at a particular **Element**.
- **approveAssociation T7** symbolizes the approval/backing association between constituents of an EA landscape.

6.2.1 Extending the Practices of The Architectural Development Method of TOGAF

The following describes the practices that we extracted from different EAM frameworks to support the proposed techniques presented in Section (6.5). They need to be part of the ‘Architecture change management’ and ‘Migration Planning’ phases of the architectural development method (ADM), which is the key element of TOGAF, please see Section (2.2.3) in Chapter (2) for more details on ADM and its phases.

The extraction of these practices is a result of examination of the literature and technical reports of various dimensions associated with the EAM landscape progression. A number of new constituents are needed to extend the meta-model used in TOGAF, see Section (6.3).

We next present the practices that should be included in any proposed meta-model to address the traceability of stakeholders’ decisions, as this set of practices is not adequately addressed in current EAM practices. The first practice is called the ‘trilogy of associations’ (P1). The second practice is called the ‘visualization of future approval of processParts’ (P2). The third practice is called ‘inference of target EA states’ (P3). The fourth practice is called ‘target EA states alternatives’ (P4). The fifth practice is called ‘traceability of

high-level stakeholders' decisions' (P5). The following presents an explanation of these practices:

- **Trilogy of associations P1** The information model should enclose a trilogy of associations to facilitate examination of existing and prospective business behaviour. The information model should clarify the approveAssociations T7 among processParts T1, EAMInfrastructure T2, and Elements T4, see the proposed meta-model, Figure (6.4). This practice is discussed comparatively in the literature ([Frank \(2002\)](#); [Garg et al. \(2006\)](#); [GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Jonkers et al. \(2005\)](#); [Niemann \(2006\)](#)).
- **Visualization of future approval of processParts P2** The information model should offer the capacity to sketch a visualization of future approval of processParts T1 and the source of approval (modelPartRole T3), with the aim of easing future states planning with no need to identify execution specifications of the processApproval T6, see the proposed meta-model, Figure (6.4). This practice is discussed comparatively in the literature ([Garg et al. \(2006\)](#); [GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Matthes et al. \(2008\)](#); [Van der Torre et al. \(2006\)](#)).
- **Inference of target EA states P3** The information model should enable the inference of target EA states from the current initiatives' activities T5. Therefore, it can facilitate the progression from the existing to target and prospect processApproval T6, see the proposed meta-model, Figure (6.4). This practice is discussed comparatively in the literature ([Frank \(2002\)](#); [Garg et al. \(2006\)](#); [Jonkers et al. \(2005\)](#); [Matthes et al. \(2008\)](#)).
- **Target EA states alternatives P4** The information model should support the formation of target EA states alternatives built on different implications of initiatives' activities T5. This is important for firmly incorporating various initiatives' activities from different perspectives, see the proposed meta-model, Figure (6.4). This practice is discussed comparatively in the literature ([Frank \(2002\)](#); [Jonkers et al. \(2005\)](#); [Niemann \(2006\)](#)).
- **Traceability of high-level stakeholders' decisions P5** The ability to save and organize knowledge from former EA states while associating them to time is significant. This

can facilitate the traceability of stakeholders' decisions. The value of this knowledge is greater if it is supplemented by details of the motives and responsibilities of these decisions, see the proposed meta-model, Figure (6.4). This practice is discussed comparatively in the literature ([Frank \(2002\)](#); [Garg et al. \(2006\)](#); [GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Jonkers et al. \(2005\)](#)).

On the other hand, we present next a set of practices required for further extent of managed progression. Throughout the early stages of our action case study, we came to the assumption that this set of practices will potentially fulfil all raised concerns to a satisfactory level. We will present references to literature supporting this assumption in the next list. However, the inclusion of further constituents to enable these practices and achieve complete satisfaction of them will increase the complexity of the solution, and eventually minimize its applicability. Therefore, we refrain from considering this set of practices for the scope of our research, with a potential future work considering them.

- Projection of drafts of future landscapes – It is significant to offer a comprehensive explanation of future application landscapes from a logical perspective, i.e. architecture blueprint. This can be facilitated by the introduction of a method and an extension to the modelling capability ([Frank \(2002\)](#); [Jonkers et al. \(2005\)](#); [Niemann \(2006\)](#)).
- Multiple states identification – The planning for a current landscape must encourage sketching the formation of a future landscape. This can be facilitated by the introduction of a method and an extension to the modelling capability ([GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Jonkers et al. \(2005\)](#); [Matthes et al. \(2008\)](#); [Van der Torre et al. \(2006\)](#)).
- Business stakeholders adaptability to future states – The transition from current to target landscape should be incremental with the involvement of stakeholders during all stages of transition. This can be facilitated by the introduction of a method and an extension to the modelling capability ([Frank \(2002\)](#); [Garg et al. \(2006\)](#); [Matthes et al. \(2008\)](#); [Van der Torre et al. \(2006\)](#)).
- Clarity of application landscape roadmap – There should be a clear documentation of all stages of change, where they are organized in sequence of time to demonstrate evolution from a current to a future application landscape. This can be facilitated by the introduction of a method and an extension to the modelling capability ([Frank](#)

(2002); [GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Jonkers et al. \(2005\)](#); [Niemann \(2006\)](#); [Van der Torre et al. \(2006\)](#))).

- Visible views for different stakeholders' concerns – The modelling capability must project views for every identified concern. It should be easy to link these views for the addressed concern. This can be facilitated by the introduction of a method and an extension to the modelling capability ([Frank \(2002\)](#); [Niemann \(2006\)](#); [Van der Torre et al. \(2006\)](#))).
- The consistent planning from high level and strategic goals to execution level – The availability of the detailed documented planning of initiatives tasks as well as decisions behind these tasks can offer a valued insight towards a future landscape. This can be facilitated by the introduction of a method and an extension to the modelling capability ([Garg et al. \(2006\)](#); [Jonkers et al. \(2005\)](#); [Matthes et al. \(2008\)](#); [Van der Torre et al. \(2006\)](#))).
- Transparency and traceability for business and technology – The ability to link components of business mental models to components of technology. This can be facilitated by the introduction of a method and an extension to the modelling capability ([Frank \(2002\)](#); [Jonkers et al. \(2005\)](#))).
- Business target depiction – A clear depiction of shared stakeholders mental model for the particular business scope. This can be facilitated by the introduction of a method and an extension to the modelling capability ([Garg et al. \(2006\)](#); [GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Niemann \(2006\)](#); [Van der Torre et al. \(2006\)](#))).

It can be generally suggested that these practices are not fully supported by different EAM frameworks. The nature of support among these frameworks varies from inclusive, partial, and missing support for each feature. A description of an inclusive meta-model of constituents from different EAM frameworks is presented in the following:

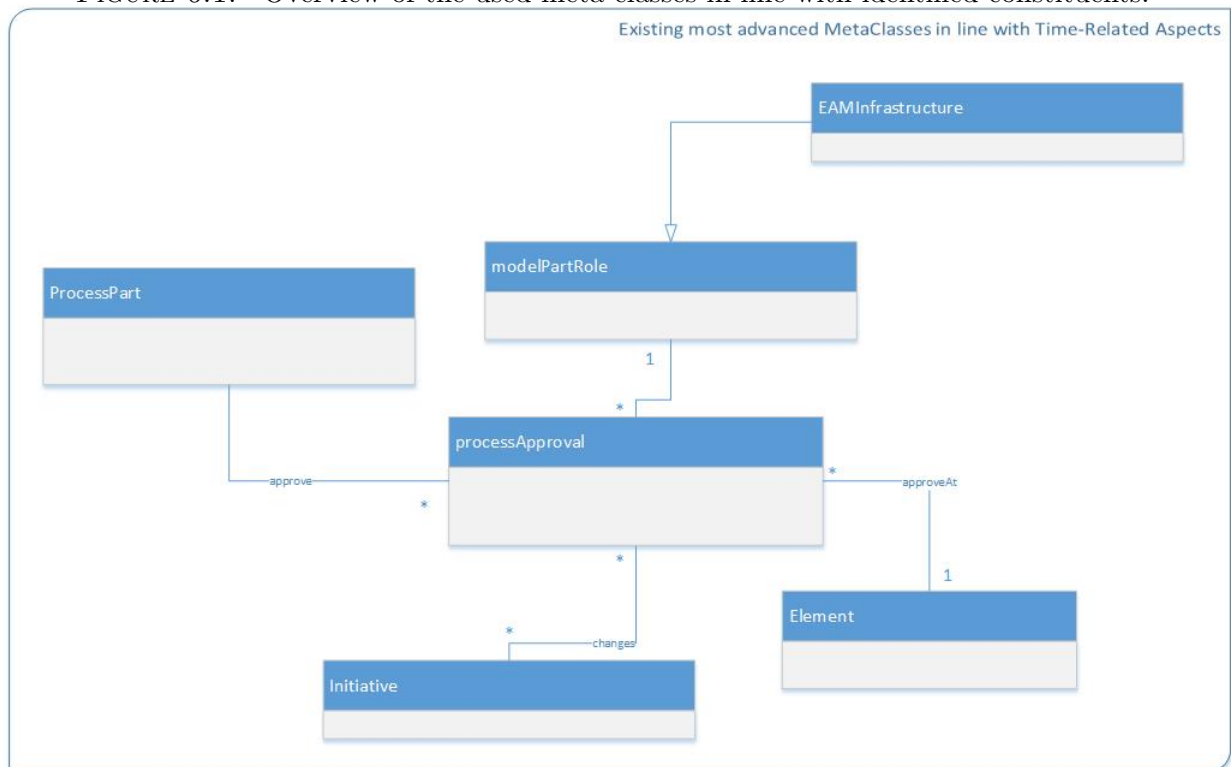
Here we describe the capacity of a meta-model comprising the constituents enabling previous practices across main EAM frameworks, in relation to the defined problem scope, i.e. in regard to the second set of desired practices, see Figure (6.1). This meta-model encloses additional constituents on top of what TOGAF offers, especially in relation to the practice of 'visualization of future approval of processParts' (i.e. modelPartRole T3), see Figure (6.1) ([The Open Group \(2009b\)](#)).

The approveAssociation T7 has attributes of an Initiative T5 life cycle in a parallel way to

an association unified modelling language (UML) class. Therefore, it is able to designate modelPartRole T3 by a particular instance of processApproval T6, which is a T6 in an exact stage/time, such as, planned, current and active. This structure outlines the level of support for upcoming states of EA as in the practice of ‘visualization of future approval of processParts’ (i.e. modelPartRole T3).

This meta-model shows how an approveAssociation T7 symbolizes connection with modelPartRole T3 for processParts T1 by EAMInfrastructure T2 at a particular Element T4; this structure fulfils partial support for the practice of ‘trilogy of associations’. At the same time, this meta-model encloses representation of time for only Initiatives T5; this structure fulfils partial support for further practices ‘inference of target EA states’ and ‘target EA states alternatives’. This has an impact on processApproval T6 and includes time details as creation and expiration of Initiatives T5; this structure fulfils support for planning the progress of the application landscape while it is not satisfactory for fulfilling the practice of ‘traceability of high-level stakeholders’ decisions’. This is because this practice would require two-dimensional time knowledge. For instance, planning EA landscape for a target year would result in different states, if it is planned from different starting points.

FIGURE 6.1: Overview of the used meta-classes in line with identified constituents.



6.2.2 Used Approaches of EAM Data Maintenance

This subsection presents the main approaches across different EAM frameworks driving their EAM data maintenance. Understanding the nature of these approaches can direct the development of our new approach. Automation is the ultimate objective of existing approaches addressing manual activities of EAM data maintenance. However, some of these approaches are focused on particular data sources and others require a large number of activities. The classification of these approaches is presented in the following list:

- Human manual collaboration and documents/Utilization of wiki – The most primitive approach to data gathering, mainly focusing on extensive interviews with involved stakeholders who are asked to fill in structured forms. This approach is a very common practice of EAM. This approach is unable to achieve the actuality of EA models. There are attempts to optimize this practice with the support of automation techniques. The utilization of a wiki is a more advanced approach. It takes advantage of Web 2.0 to manage data gathering to update EA models. It has the advantage of the participation of a higher number of stakeholders to improve the quality of EA models, while the two kinds of offered wikis are semantic and hybrid. This approach is discussed to a certain degree in the literature ([Ahlemann et al. \(2012\)](#); [Buckl et al. \(2011d\)](#); [Fuchs-Kittowski and Faust \(2008\)](#); [Happel and Seedorf \(2008\)](#); [Lankhorst \(2009\)](#)).
- Structured data gathering methods – The following progression includes the pre-identified methods assigning gathering tasks to stakeholders with supporting identified tasks. This approach has offered no notions of context adoption. This approach is mainly driven by the literature ([Farwick et al. \(2012\)](#); [Moser et al. \(2009\)](#)).
- Abstract notion of import – A number of authors have highlighted this import approach. Most of these proposals are basic and do not offer guidance on implementation. There is some advanced work proposing constituents of an execution tool ([Fuchs-Kittowski and Faust \(2008\)](#); [Lankhorst \(2009\)](#)). This approach is driven by practice and the literature ([Brückmann et al. \(2011\)](#); [Frank et al. \(2009\)](#); [Fuchs-Kittowski and Faust \(2008\)](#); [Laube et al. \(2012\)](#); [Sousa et al. \(2011\)](#)).

- Basic techniques/models of causal update – This approach built on the idea of exploiting and integrating current techniques/models to EAM. A big concern of this approach is transition and mapping among different techniques/models. The transition is an important point of research, with consideration of the semantics behind various models into an inclusive repository. This approach is discussed to a certain degree in the literature ([Arbaba et al. \(2007\)](#); [Chen et al. \(2013\)](#); [Lankhorst \(2009\)](#); [Schmidt \(2008\)](#); [Ter Doest et al. \(2004\)](#))
- Optimizing manual activities based on particular data sources – A thorough account of integration based on particular data sources is offered in the listed publications. To be exact, most of the work in this approach is restricted to a single architectural layer. In addition, the attempts here do not offer processes for maintaining the actuality of the gathered data. This approach is discussed to a certain degree in the literature ([Alegria and Vasconcelos \(2010\)](#); [Buschle et al. \(2012\)](#); [Holm et al. \(2014\)](#)).
- Triggering events – This approach concentrates on the impact of capturing indications from external IS that generate transformation of the EA landscape. Part of the work focuses on the value of obtaining external indications. The rest also focus on generators of transformation and how to offer underlying support. A recent study initiated execution aspects to accelerate automation. This approach is discussed to a certain degree in the literature ([Ahlemann et al. \(2012\)](#); [Buckl et al. \(2011b\)](#); [Farwick et al. \(2012\)](#); [Sousa et al. \(2011\)](#)).
- Transformation and correctness notification – This approach examines handling variation across different states of the EA landscape to ensure actuality in the cases of automation. Some attempts were presented to guide the execution aspects of various methods. This approach is discussed to a certain degree in the literature ([Fischer et al. \(2007\)](#); [McClure \(2006\)](#); [Moser et al. \(2009\)](#)).

All in all, the outlined classification presents an insight into the limited approaches of data maintenance automation in the field of EAM. These attempts are not endorsed yet and there is no current formal integration with a driving methodology.

6.2.3 The Theoretical Relation between Business Behaviour and Data Maintenance

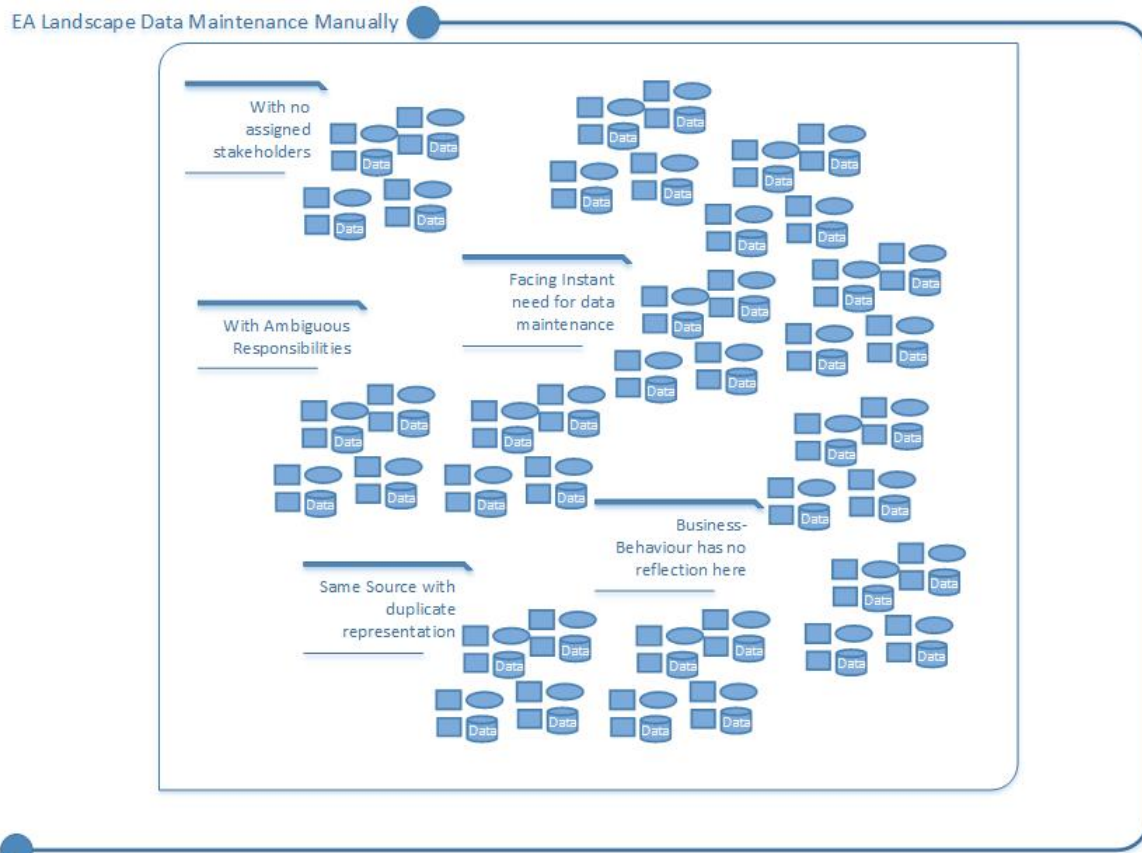
EAM models represent business aspects of the organization and they document the associations between these models on one side to the technological infrastructure and related information systems on the other ([Winter and Fischer \(2006\)](#)). The resulting EA models help to examine the existing state of the EA landscape to steer change to target representation of the EA landscape ([Aier and Gleichauf \(2010a\)](#)).

Recent examinations of the literature have highlighted the challenges associated with the management of business behaviour including, firstly, collaboration between different organizational units and second, proper representation of the EAM landscape considering the understandability of different stakeholders, and third reducing the complexity of the constantly changing EA landscape in addition to fourth, the existing partiality of manual modelling ([Arbaba et al. \(2007\)](#); [Buckl et al. \(2009a\)](#); [Lucke et al. \(2010\)](#); [Winter and Fischer \(2006\)](#)). It is encouraged by the literature to address these challenges of EAM practice. A thorough account of the first challenge can be found in [Lucke et al. \(2010\)](#) and [Winter and Fischer \(2006\)](#). A thorough account of the second and third challenges can be found in [Buckl et al. \(2009a\)](#) and [Winter and Fischer \(2006\)](#). A thorough account of the fourth challenge can be found in [Arbaba et al. \(2007\)](#) and [Winter and Fischer \(2006\)](#).

The constructed EA models of a large enterprise are complex and broad considering the representation of every architectural level. Therefore, practically, it is challenging to manage the actuality of these models at all times reflecting the up-to-date state. Recent studies have stated the significance of addressing this challenge ([Farwick et al. \(2011, 2013\)](#)). A number of other studies have highlighted indications supporting the value of this contribution ([Kaisler et al. \(2005\)](#); [Winter et al. \(2010\)](#)). Nevertheless, EAM frameworks and supporting literature offer minimal recommendations for handling the issue.

There are a number of data maintenance automation approaches ([Buschle et al. \(2012\)](#); [Farwick et al. \(2011\)](#); [Holm et al. \(2014\)](#)). Although, these approaches concentrate on data gathering and its inclusion in EA models. It is indicated that there are a number of obstacles facing automated data import into EA representations ([Farwick et al. \(2013\)](#); [Hauder et al. \(2012\)](#)). This research outlines that every enterprise has its own context-related data maintenance issues. This claim is supported by discussion in [Aier et al. \(2011\)](#), as it highlights the importance of methodological adaptations for enterprises' context.

FIGURE 6.2: The correlation of EA landscape between business behaviour and EA models maintenance.



6.3 Extended Underlying Meta-Model

A structure of EAM frameworks comprises the methodology managing EAM implementation supported with the underlying meta-model to represent the landscape. Sections (6.4) and (6.5) offer a number of practices that can be integrated to ADM of TOGAF and extend on its practices to deal with change to reflect actual representation of the EA landscape.

Therefore, we offer an extended meta-model capable of fulfilling the requirements of these new techniques, because these techniques will produce EA modules and they will require a meta-model with the capacity to represent different new product parts. Section (6.5) offers more details on the new product parts. The meta-modelling principles of MOF ([Object Management Group \(2006\)](#)) are followed by our proposed meta-model.

Therefore, with the aim of offering a foundation for future tool support that is able to generate and maintain the language side of EAM, we extend and offer a meta-model that enables the representation of context-related EA models. It covers additional elements, such as period, identification constraints, and rejected directory.

The constituents of the meta-model comprise the contextual elements guiding change management within EAM in reality. The information models generated on the basis of this meta-model will be able to represent the following model elements: stakeholders' needed data, time of change, source of information, elements of change, actuality assessments, and assigned stakeholders for manual activities.

In reality, elements of the meta-model were modelled/instantiated with the help of an EAM tool, using a number of means/syntax, such as UML class-diagrams or others. The used tool in our action case study is TOGAF 9 method plug-in for the open source Eclipse Process Framework Composer tool ([The Open Group \(2009b\)](#)). In practice, the tool was used to carry out specific tasks via its form-based flow. An instance of such tasks is responsibilities allocation or constraints identification.

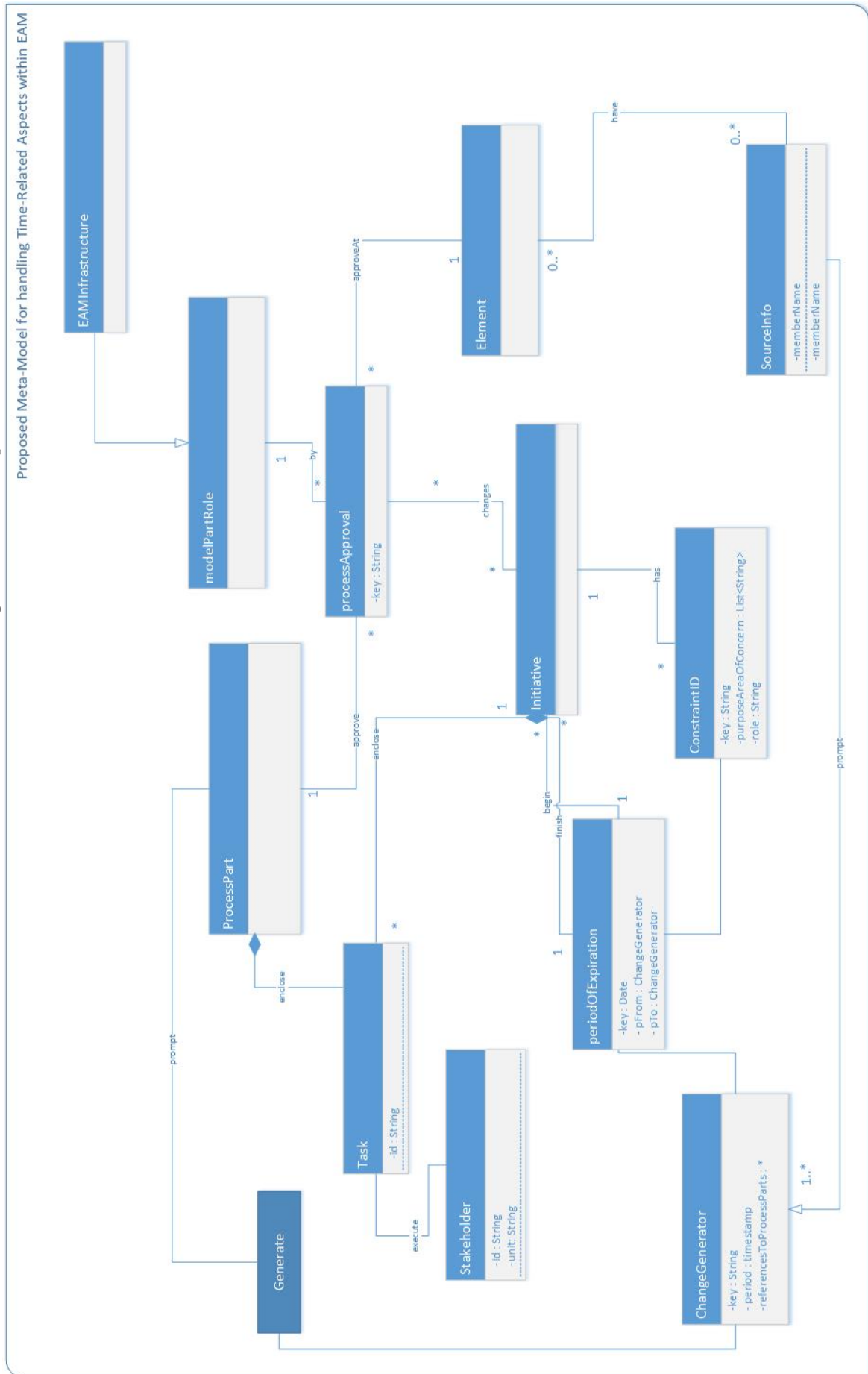
The following will explain all constituents of the proposed meta-model. These constituents will be categorized into four categories reflecting the requirements of the four proposed techniques. These four techniques are presented in Section (6.5).

Figure (6.3)¹ presents an overview of our extended meta-model. This meta-model aims to enable the data gathering practices discussed in Section (6.5). These practices maintain the availability of up-to-date data resulting from any change affecting the enterprise in order to be incorporated in their EA representation. This proper representation ensures the actuality of EAM to drive the realization of high level goals. We highlight that naming the new constituents might overlap with terms used in different EAM frameworks, but we constrain our constituents to our definition and context.

¹The resolution of the figures is high in the electronic copy of the thesis, which enables zooming in for clear classes and associations.

The extended meta-classes and their association will be supported by further meta-classes to handle time-knowledge within their practices, see Figure (6.4). The new constituents aim to achieve satisfactory fulfilment of time-knowledge aspects, which were presented in Chapter (5). The importance of these aspects is to reach constant responsiveness to change in an EA representation. These new time-knowledge constituents form the fifth category of new constituents and are discussed at the end of this Section (6.3).

FIGURE 6.4: Overview of the meta-model for handling time-related aspects within EAM.



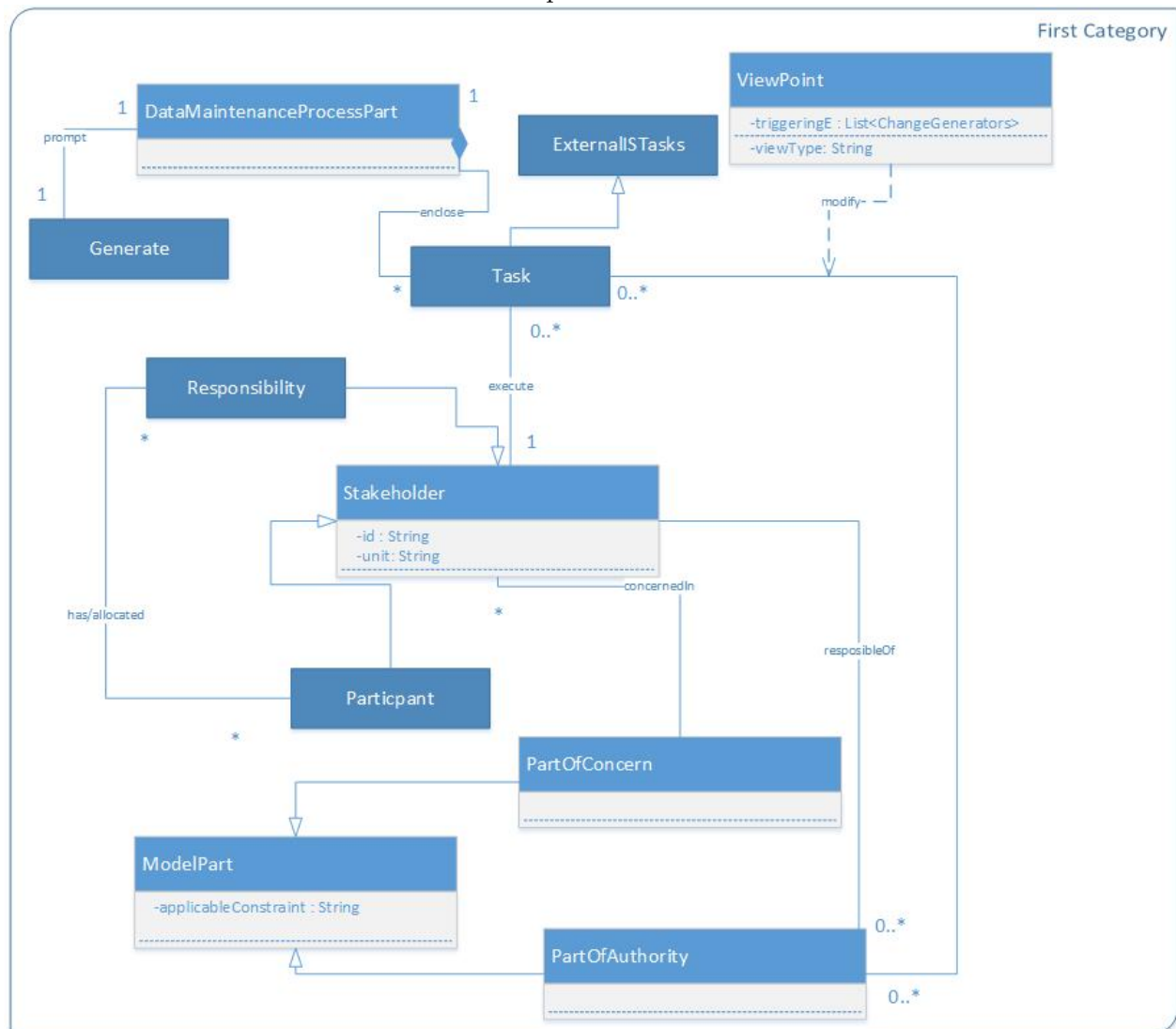
The following identifies the new constituents that aims to provide further capacity needed in our solution. In addition, we identify the structure of the new meta classes, their attributes, and their associations, which fall under each category, see Figures (6.5), (6.6), (6.7), and (6.8). Afterwards, Section (6.5) describes the actual employment of these constituents supported with guidelines.

First category: maintenance of process parts, see Figure (6.5)

This category is in charge of modelling the four techniques that are described in Section (6.5). **First proposed constituent: DataMaintenanceProcessPart** comprises tasks; every task deals with the handling of the **second proposed constituent: PartOfAuthority**. PartOfAuthority is a subclass of the **third proposed constituent: ModelPart** which gathers different parts of EA models. The handling of different model parts is enclosed within the **fourth proposed constituent: PartOfConcern** and carried out through viewpoint representation. The viewpoint is offered in EAM tools to deal with transformations.

Stakeholders are in charge for implementing tasks assigned to relative PartOfAuthority. The assignment is completed by either participant or responsibility. Stakeholders are associated with PartOfConcern. The assembly of these constituents are utilized to notify stakeholders about any transformation/change. Any employed tool will enable such modelling by choosing from pre-structured processes. It will also provide pre-designed viewpoints to be chosen.

FIGURE 6.5: Overview of the meta-classes of the first category: maintenance of process parts.



Second category: independent change generators, see Figure (6.6)

IndependentCGs are a specialization from **SourceInfo**. **SourceInfo** has a distinctive key, in-charge stakeholder, in addition to independent keys that list rejected triggering events. **SourceInfo** adopts instances of particular **ModelParts**. In the other direction, these instances of matching type can be accessed from a number of **SourceInfos**, while **SourceInfo** is able to bring up the following types of **IndependentCGs**:

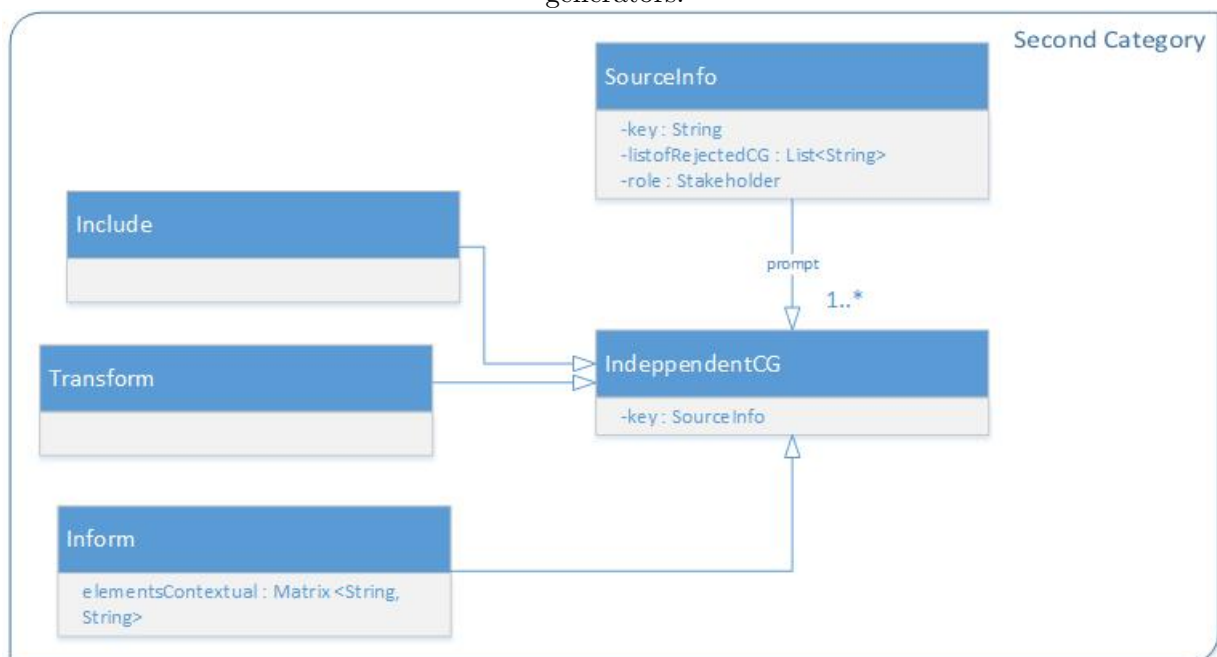
First proposed constituent: Include is a type of **IndependentCG** which implies a recently discovered **ModelPart** with uncertainty of the actuality of this part yet. In practice, tools will be used to fuse it to the respective actual part.

Second proposed constituent: Transform is a type of **IndependentCG** which implies an already approved and merged **ModelPart**. **Include** and **Transform** are vital to our approach towards constant maintenance of EA models, in association with the first and second technique. So they constitute a significant part of the proposed meta-model.

Third proposed constituent: Inform is a type of **IndependentCG** that is invoked by external systems with no defined source of information. So they use this type to inform identified stakeholders once variation in actuality occurs, i.e. notification of changes. An instance of the external system is project portfolio management. An instance of the expected notification from such a system is a project ‘meeting the target’, prompted from the processes within the system. Every **IndependentCG** contains contextual details in the form of distinctive keys; this is basic and can be enhanced. These details can be illustrated via the resultant viewpoint representing **IndependentCGs**.

Include, Transform and Inform are linked to **Element** which holds information, including the preceding change date. This information will be utilized to advise stakeholders of the expiration period of **ModelParts** and eventually the expiration period of the overall **PartOfConcern**.

FIGURE 6.6: Overview of the meta-classes of the second category: independent change generators.



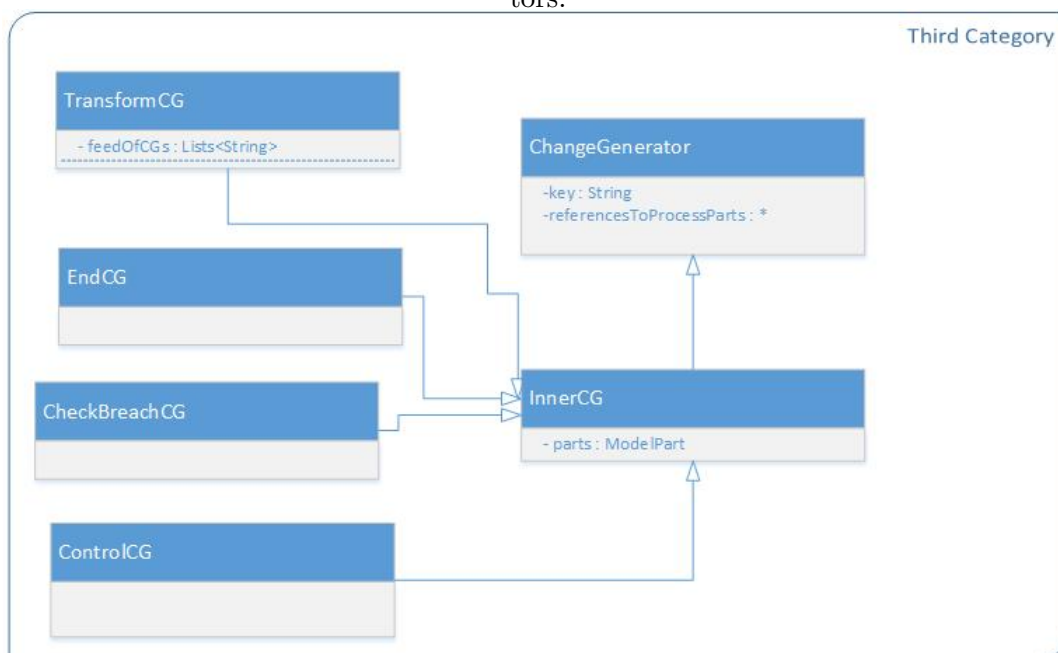
Third category: inner change generators, see Figure (6.7).

InnerCGs are prompted from within EAM as they point to structured sources of information and they hold a number of influenced **ModelParts** assembling a **PartOfConcern**.

First proposed constituent: CheckBreachCGs are employed to generate manual assessment check of actuality if a particular constraint is breached. For instance, if project portfolio management, as an external system, is still running a project after its expiration period, then **CheckBreachCGs** can be used to ask an appropriate stakeholder to examine this breach and transform the EA models.

This category reflects the fourth technique process part. First, **second proposed constituent: EndCG** asks a stakeholder for an assessment check for a particular **ModelPart** after a defined period of no change. Second, **third proposed constituent: ControlCGs** are employed for the purpose of the first technique as it is prompted after scheduled periods to carry out routine checks. Third, **fourth proposed constituent: TransformCGs** are employed when the corresponding **ModelParts** change. In practice, EndCG, ControlCG, and TransformCG are utilized by an EAM tool to inform stakeholders once changes occur to particular ModelParts.

FIGURE 6.7: Overview of the meta-classes of the third category: inner change generators.



Fourth category: identification constraints, see Figure (6.8).

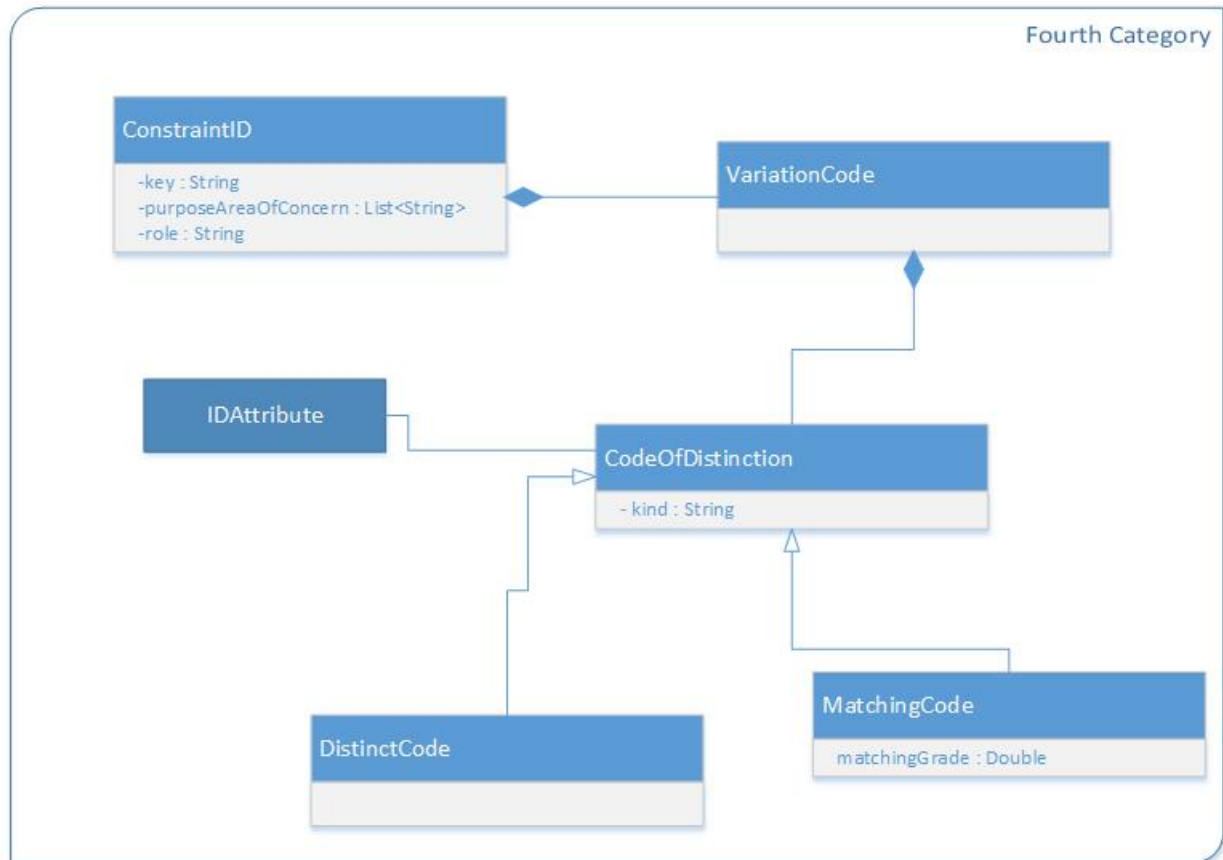
The aim is to aid EAM to prevent identical **ModelParts** being initiated from diverse **SourceInfos** or even being manually initiated. The proposed meta-model enables the recognition of duplicates as well as integrating them. The occurrence of duplicates might happen when utilizing the second technique. See Figure (6.3) for an illustration of the ties between constituents of the meta-model.

First proposed constituent: ConstraintID is assigned to determine the credentials whether two **ModelParts** are pointing out to an identical component. **ConstraintID** comprises a number of **second proposed constituent: VariationCodes** which comprises a number of **third proposed constituent: CodeOfDistinction** that holds **fourth proposed constituent: IDAttribute** which is a specialization of a general property.

It basically signifies that this property allows **CodeOfDistinction** to be exercised on it. **CodeOfDistinction** is either **DistinctCode** or **MatchingCode**. When **DistinctCode** is valid, it designates identification credentials of different **ModelParts**. This constituent might be employed to recognize two **ModelParts** as one.

MatchingCode is employed if **DistinctCode** is not applicable. This constituent might be employed to compare the **IDAttributes** of **ModelParts** and their resemblance. These conclude a matching grade as the foundation for a stakeholder's verdict on integrating different **ModelParts**. In reality, the proposed meta-model will be instantiated with a number of tools rather than one.

FIGURE 6.8: Overview of the meta-classes of the fourth category: identification constraints.



To this point, we have proposed and described our underlying meta-model with a capacity to satisfy the requirements of the four techniques presented in Section (6.5). In reality, the proposed meta-model will be instantiated with a number of tools rather than one, and occasionally one tool with a number of views. Relatively, these tools are employed to produce a presentation that is the structure of `productParts` and `processParts`, EA models, in addition to the configurations of `changeGenerators` and `identificationConstraints`. These components are connected in the actual execution. For instance, the configuration of `changeGenerators` only holds the key and process part to prompt the generator. Therefore, the connections among `ModelParts` need responsiveness.

Fifth Category: New constituents for handling time-related aspects within EAM, see Figure (6.4).

This part describes an extended part of our meta-model addressing the previously extracted time-related aspects within EAM that were presented in Chapter (5), see Figure (6.4). In order to offer a coherent explanation of the meta-model, we begin with explaining the used modelling concepts of time-knowledge/temporality. In addition, we present an approach supporting the construction of chronological models with focus on patterns for purposes that transform sequentially (Anderson (1999); Carlson et al. (1999)). Moreover, we concisely refer to time-based databases as a primary way for clarifying chronological dependencies. Then, we identify the main structure of a meta-model able to adopt the previously stated difficulties. The following presents an overview of the related work of the modelling of sequential patterns.

We describe in brief how two prominent techniques handle time-knowledge within their practices. We will utilize their techniques, which are commonly used in practice, to obtain constituents to be part of our proposed meta-model. We emphasize that the patterns used in their original form might affect the usability of the solution. In addition, they offer a future research point for developments on top of the EAM pattern catalog, see Chapter (2) for more details on the catalog. Therefore, we benefit from their practices as explained next.

The reoccurring issue of the best approach to integrate time-knowledge to information models has been continually examined in a number of subjects. The area of database research derives a major approach to this issue, in which chronological databases are initiated as a way of representing two-dimensional association to sequential modelling. This refers to the representation of entities that transform constantly, while all past states need to be reserved and accessible.

Therefore, we present briefly the key concepts of their two-dimensional chronological modelling. A detailed review of the subject within the area of database research can be found in Snodgrass (1999). For clarification, an uncomplicated timestamp can be included as an additional column in a database that contains time-related details. In this way, it enables the recognition of the validity of a particular table row at a particular moment. The weakness of this preliminary solution is that it is not instantly possible to identify that a particular row is valid for a precise duration.

However, this weakness can be overcome by including an additional column for maintaining the end of the duration of applicability. Further attributes should be identified to enable the traceability of changes in addition to the applicability's duration. At least two more attributes need to be included to realize traceability of changes, maintaining additional time-related details (Anderson (1999); Carlson et al. (1999)). The details identify a particular duration of applicability and consequently maintain the succession of transformation states.

Parallel work on the integration of time-related dependencies is done in the subject of object-oriented modelling. A resulting group of chronological/sequential patterns has been produced (Carlson et al. (1999)). A detailed review of the subject within the area of object-oriented modelling can be found in Anderson (1999). Next, we present the key time-knowledge concepts in these patterns, as they are frequently utilized in two-dimensional sequential models. We benefit from the previous practices and integrate the following two extracted concepts into our proposed meta-model.

- An **changeGenerator** generates a transformation or progression of state in a model. The generation point of time needs to be reserved, therefore a timestamp is linked to the changeGenerator, see meta-model Figure (6.4). In line with Anderson (1999), how to signify changeGenerator is up to the practitioners of the employing field, but we choose to represent it as a meta-class due to the clarity principle.
- A **periodOfExpiration** has an explicit start-changeGenerator and end-changeGenerator. This enables the inference of the period of expiration, such as the initiatives' life cycle.

These key time-knowledge concepts in these patterns deal with particular time-related design concerns. One of the common sequential patterns is called 'historical mapping'; refer to Fowler (2008) and Carlson et al. (1999) for a comprehensive discussion. This pattern is useful for traceability of changes. Thus, the 'historical mapping' allocates the duration of applicability to the relevant element, in order to reveal that this particular element is valid for this distinct period.

In order to realize the traceability, in case the changeGenerator is not represented as a meta-class, it is then transformed to an instance class. This class encloses the relevant value in addition to two added attributes signifying the start and end of the duration of applicability. It should be noted that this might add further complexity to the relevant model by the initiation of a further class, as a consequence of utilizing the pattern to deal with time dependencies. Therefore, we represent changeGenerator as a meta-class.

A number of patterns in [Carlson et al. \(1999\)](#) can be employed on the T7 process. Approved, as it essentially signifies a trilogy of associations. A detailed overview of the pattern can be found in [Carlson et al. \(1999\)](#). This is done with the aim of fulfilling the features formerly explained, in particular the fourth and fifth features. These patterns as in ‘temporal-association pattern’ enclose attributes parallel to the previous pattern for the purpose of the duration of applicability. In relation to EA landscape management, this pattern enables the comparison between different states produced at different points of time for the same target, i.e. at the same point of time. This is done with the aim of fulfilling the fifth feature as formerly explained, where the details relating to the points in time of when the relevant initiative state was produced are considered. The set of time-related patterns in [Carlson et al. \(1999\)](#) can be utilized to realize the previous points.

Not all time-knowledge features are satisfactorily fulfilled; a detailed description is presented next. In addition, the integration of the core constituents is not completely fulfilled for the following two reasons:

- The **changes** association does not differentiate visibly between the diverse forms of changes; an initiative can comprise Include, Transform, and Inform.
- **Initiatives** not only transform processApproval T6 and approveAssociation T7, but also change EAMInfrastructure T2. In effect, initiatives mainly transform EAMInfrastructure T2 causing transformations to processApproval T6 and approveAssociation T7.

In order to address the first issue, two associations need to be established to perform the changes association. The two introduced associations reflect the start and end of the initiative. Consequently, the migration of the initiative is signified by utilizing the cooperation of the two associations. Therefore, the resolution of the first issue can be considered simple.

On the contrary, the second issue is more difficult to resolve. Therefore, initiatives and tasks within initiatives should be connected to every changeable element. These associations can be realized by means of distinctive initiatives’ task types that influence only EAMInfrastructure T2 and processApproval T6. In order to achieve the ideal representation, architects should establish a primitive constituent for every kind of changeable part. Therefore, when it is influenced by an initiative or tasks within initiatives, the particular instance of the meta-class can be used in the model.

In addition, we progress our solution and initiate the particular primitive constituent and its relationships to initiatives' tasks. The latter are utilized to model distinctive tasks in an initiative. Figure (6.4) illustrates the meta-model integrating these notions. Within the proposed meta-model, any initiative, which is influenced by 'changes' association, can originate its periodOfExpiration from the start/end points of time relating to connected influential initiatives. Thus, an instance of this influenced initiative enables the allocation of initiatives' dependencies to a concept within an EA model.

However, choosing the utilization of a common UML inheritance notation will not enable stakeholders from different backgrounds to comprehend the model clearly. There are a large number of instances expected to be derived from this initiative with dependency, so we initiate another stereotype called 'initiatedepend' that can be allocated to a class to signify that it is a subclass of initiative with dependency. This can be done to produce a less complicated and more concise model.

The integration of notations in Figure (6.4) offers a meta-model fulfilling the features P1, P2, P3 and P5 as well as the possible utilization of the new stereotype 'initiatedepend'. The meta-model represented in Figure (6.4) addresses also the fourth feature to a satisfying level. Target EA landscape states alternatives /variations can be originated at any moment, built on different time-knowledge details of a particular initiative. However, these states are not reserved, since the model does not enclose a constituent for maintaining diverse initiatives and states varieties. This should not be considered an important weakness, as initiative variations are known to be employed in dialogues with other fields, such as for project portfolio management. Moreover, there is a need for a number of further constituents in order to enable the reservation of diverse variations, and also to reserve more complicated diverse timelines for the initiatives in a continuing application landscape planning. This would cause practical concerns, as architects will not favour such complications, and stakeholders will not comprehend such models. In addition, the resulting complexity in generating model instances may not balance the gained advantages of this supplementary mechanism of targets planning.

6.4 The Modelling of Business Behaviour

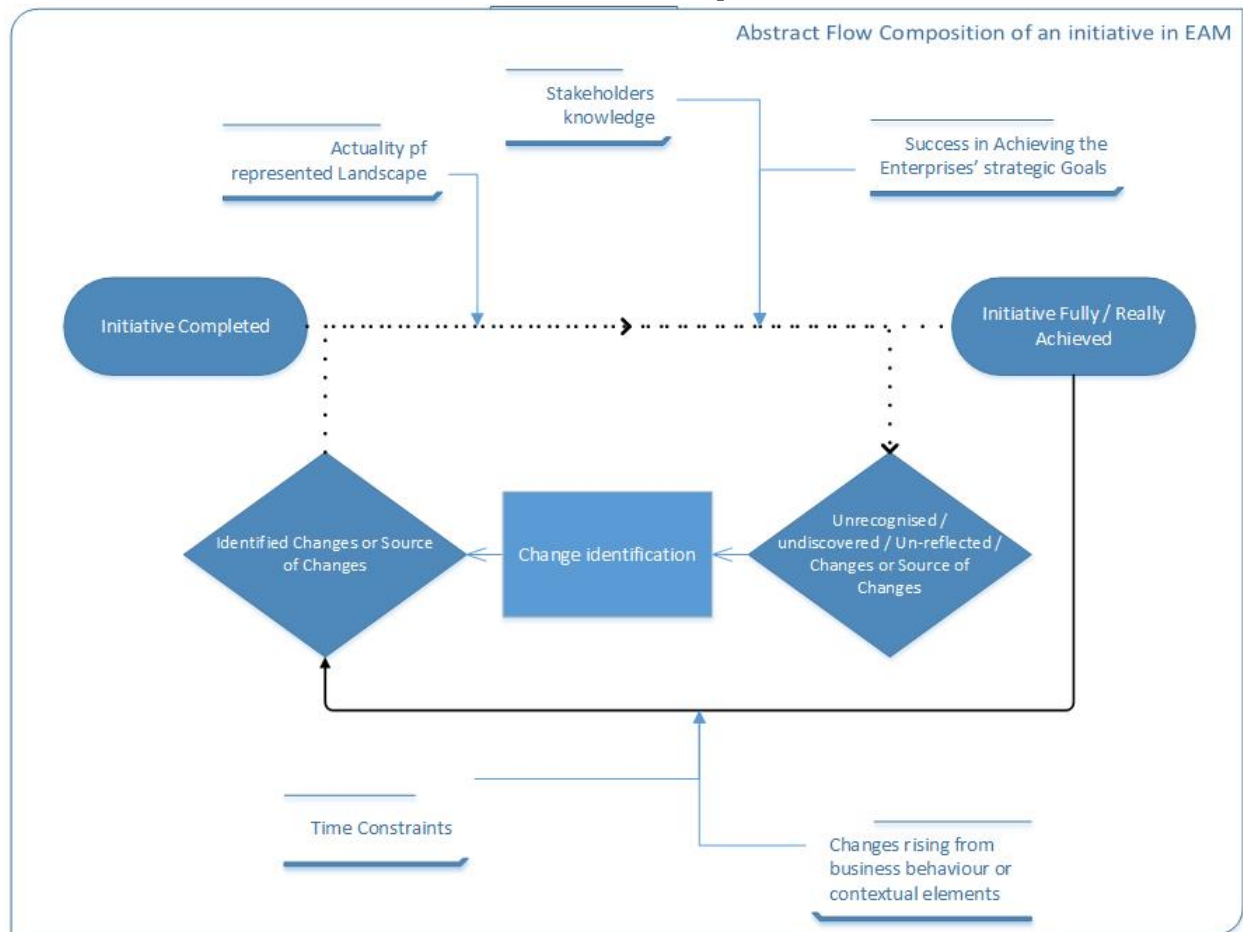
The significance of an agreed-on application landscape design is key to the success of EAM. The ability to offer a design agreed on and shared by diverse stakeholders is vital to the realization of the EAM function. In practice, different stakeholders hold different mental models of the application landscape. We aim to offer models enabling stakeholders to have shared understanding and shared architectural thinking.

Therefore, we put forward the employment of a number of guidelines on top of current methods. These guidelines facilitate the modelling of stakeholders' behaviour and their decision implications. This is clear when a decision is made in regard to a new initiative affecting the presentation of EA, i.e. an initiative is a parallel term to a project in TOGAF. An overview of an abstract flow composition of an initiative within the EAM landscape is presented in Figure (6.9). This modelling comprises embedded application landscape progression principles that do not exist in formal guidelines but in the minds of the diverse stakeholders. In order to achieve this, we extract a few guidelines from the literature for building a desired mechanism.

The best way to simply define the mechanism is to include a solid causal loop representation on the utilized technological standardization. In the evaluation chapter, an evaluation derived from the action case study illustrates the validity of the guidelines and model constituents in addition to the modelling mechanism's appropriateness to improve interaction between diverse stakeholders in enterprises.

We highlighted one area as a possible source of driving guidelines; this area is business dynamics modelling (BDM). BDM is capable of providing a strong instrument by incorporating the mathematical and practical sides of practice (Forrester (1997); Sterman (1994)). It is a means of grasping the behaviour of composite systems. The principles of business dynamics modelling are offered as guidelines to be utilized on more than one model type (Homer and Oliva (2001)), see subSection (6.4.3) for more details.

FIGURE 6.9: Overview of an abstract flow composition of an initiative in EAM.



Causal loop diagrams (CLDs) compile correlated organization's constituents and their associated causal formation, which are represented as arrows. A plus symbol signifies a constructive relation between two elements. A minus symbol signifies a nonconstructive relation, which is opposite direction transformation. Accordingly, a closed loop with a plus or minus symbol has a strengthening or deteriorating consequence on the relative organization's constituents. The symbol signifying the loop type is placed in the middle of the loop, supplemented by a name to ease the readability. In addition, a designer can add a time delay sign (two parallel lines) as a consequence of behaviour that might have a delaying impact (Stermann (2000)). Moreover, iterative verification is required for the assumptions behind the causal formation.

6.4.1 The Implications on Target EA Landscape by Supporting Collective Thinking

The construction of EAM models, including the different application landscape versions, requires the agreement of various stakeholders in the enterprise. This means they have to have a collective understanding of the purpose, difficulties, data, and respective models, which can complement the management decisions and minimize inconsistency as well as more valuable architectural thinking (Weiss et al. (2013)). This has a number of benefits on application landscape design:

- Stakeholders having shared understanding across different units in the enterprise enables them to construct future models and recognize events changing the status of the application landscape as well as making fast decisions at run-time (Maynard and Gilson (2014)).
- The construction of models comprising practical behaviour enables stakeholders to learn and improve their models (Sterman (2000)).
- The current practices of the repeated acquisition of such knowledge manually are harder and more time consuming. In addition, in some cases, the implications of these models are built in separate models.
- Business dynamics modelling eases the materialization of shared mental models among EA architects, where decisions are built on practical behaviour and feedback, while the guidelines will also help in establishing how to utilize this input.
- The ability to materialize this implicit knowledge would be significant in crucial decision-making, rather than manually taking into consideration all causes and effects (Dörner (1990)).

6.4.2 The Proposed Guidelines for Modelling Business Behaviour

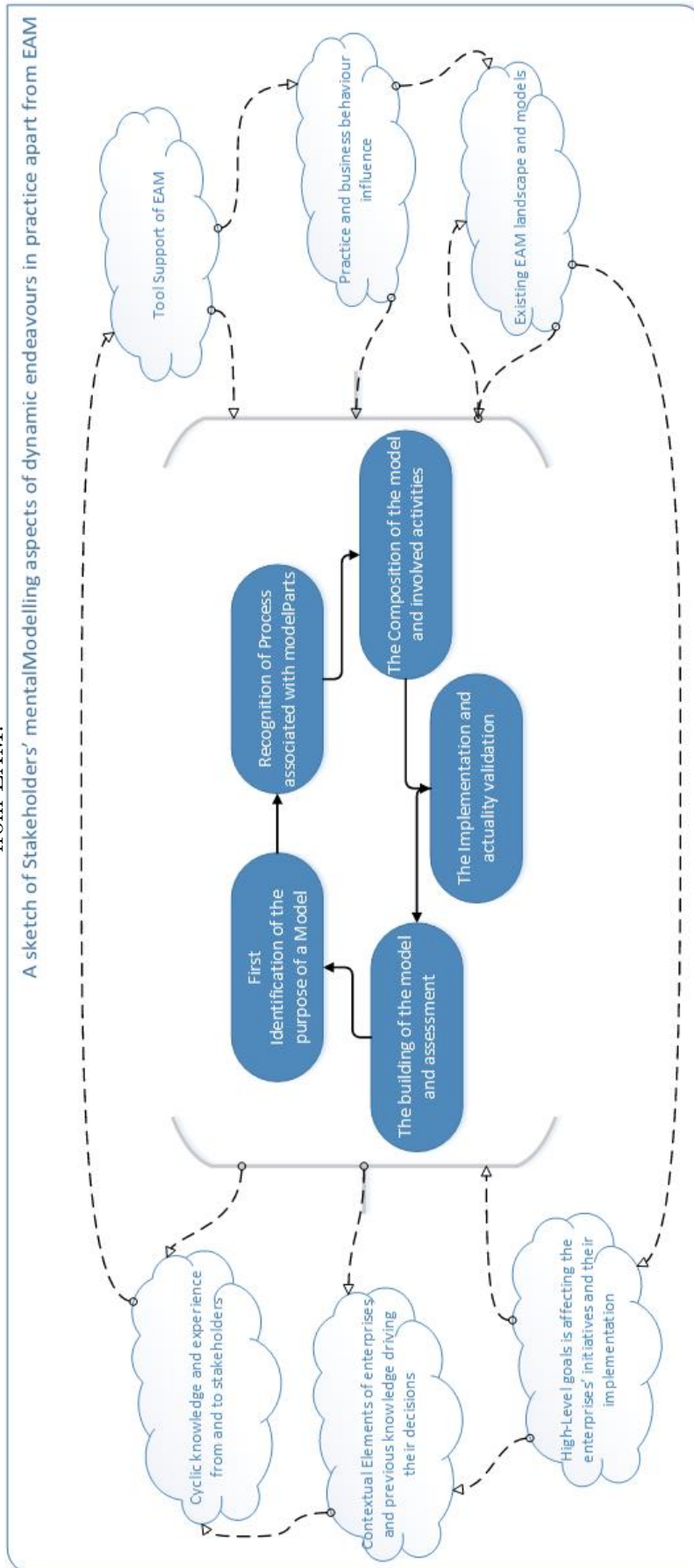
Bearing in mind that business dynamics modelling is well established in science (Forrester (1997)) and practice (Sterman (2000)), EAM has not so far embraced and implemented its principles. We present in Figure (6.10) a sketch of stakeholders' collective-thinking/mental-modelling aspects of business behaviour dynamics. This might be caused by the lack of clear technique to develop it in enterprises. This is justified on the grounds of assuming the familiarity of experienced architects with its principles. Another cause is the ignorance of specifics within enterprises as current methods are very general (Luna-Reyes and Andersen

(2003); Sterman (2000)). Designing a mechanism is complex, as it entails clear activities, their order of implementation, a meta-model, and a suitable procedure. In order to facilitate the realization of this objective, we extract a few guidelines from the literature for building the desired mechanism, taking into consideration the EAM nature. The ability to offer such guidelines will present the foundation for a desired mechanism. We present next the proposed guidelines for the modelling of business behaviour:

- The first guideline: **start modelling with the aim of generalization** – This guideline manages the modelling with the following instructions: –Set a target for every model, identify the scope and do not include unnecessary data (Sterman (2000, 2002)). –Within EAM, precise level of detail is more vital than completeness (Farwick et al. (2011)). –Modelling must consider and cover data commonly ignored. –Models should be built in a way to encourage learning for future modelling by inclusion of behaviour in practice, in order to enable communication.
- The second guideline: **collect data from diverse stakeholders** – This guideline manages the modelling with the following instructions: –Studies have shown that better solutions are reached by variety of contributions and contributors (Isaksen and Treffinger (1985)). –Heterogeneous input results in improved models which benefits a wider range of stakeholders. –Heterogeneous stakeholders are needed to produce future EA landscape versions (Weiss et al. (2013)).
- The third guideline: **establish both divergent as well as convergent construction stage** – This guideline manages the modelling with the following instructions: –Begin with a divergent stage, after that a convergent stage (Isaksen and Treffinger (1985); Jonassen (1997)). –In the divergent stage: name potential representations/solutions with no partiality. –In the convergent stage: analyse alternatives and eliminate methodologically. –The data should be gathered from different units with no dependency, gather all proposals with no partiality among stakeholders, afterwards start analysis of the solutions. –In the convergent stage: joint discussions/meetings of group/team modelling require experienced architects.
- The fourth guideline: **maintaining clarity and simplicity** – This guideline manages the modelling with the following instructions: –The only way to ensure the actuality of EA models is to offer clear traceability to the sources of models constituents (Wegmann (2002)). –In order to facilitate the previous point, causal implications should be offered and documented for clarity and reliance. –Key elements of the previous documentation: stakeholders' responsibilities, time and utilized mechanism.

- The fifth guideline: **recursive authentication through input** – This guideline manages the modelling with the following instructions: –Analysis of composite organization’s functions is an appropriate way to be familiar with implied decisions ([Senge \(1990\)](#); [Sterman \(2000\)](#)). –In particular when multiple-attempts cannot be carried out in practice as in EA landscape modelling. –Facilitate quicker learning and future enhancements through redefinition of business context recursively ([Checkland \(1985\)](#)).

FIGURE 6.10: A sketch of stakeholders' collective-thinking/mental-modelling aspects of business behaviour dynamics in practice apart from EAM.



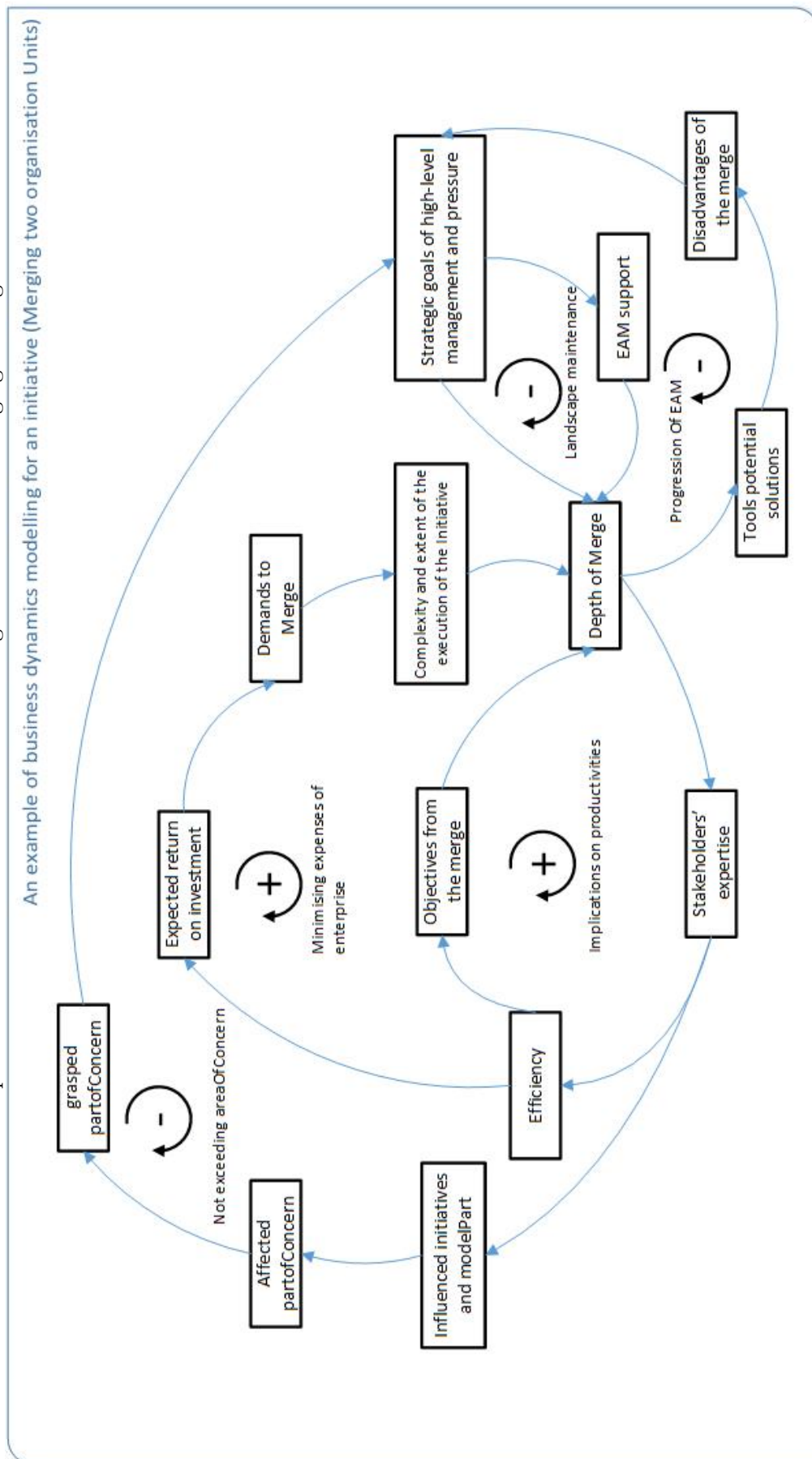
6.4.3 An Example of Modelling the Business Behaviour Surrounding an Initiative Modelling

Figure (6.11) offers an example of the business behaviour modelling guidelines illustrated in the preceding sections. This is an example of the causal loop diagrams (CLD). CLD is the common model type of business dynamics modelling. CLDs offer a comprehensive outlook on causalities in an organization's system, in order to enable representing a more complete and expressive view of the structure of the system. We built an example causal loop diagram for the modelling approach of an initiative: the initiative of merging two organizations' units. Prior to the start of the modelling, the terms of the area of the model need to be agreed on. We began by obtaining a group of dynamic hypotheses based on the literature and previous action studies (Buckl et al. (2013); Homer and Oliva (2001); Sein et al. (2011)).

1. Brain-storming with EA architects with no external interaction
2. Examining and aligning the identified hypotheses (third guideline)
3. Structuring the hypotheses and representing the collected input while validating (fourth and fifth guidelines)
4. Allowing a period for learning (first guideline)
5. Linking varied roles and stakeholders to the hypotheses maintaining heterogeneity (second guideline)
6. Integrating the constructed models by merging repeated elements, see Figure (6.11) depicting interrelations and impact levels

The previous activities will result in structuring the dynamic hypotheses of the example with consideration of the proposed guidelines. The following resulting hypotheses are produced for the purpose of providing architects, who are going to model the initiative, with a set of causal effects representing context information. The dynamic hypotheses are named next: implications on productivities, landscape maintenance, progression of EAM function, minimizing expenses of the enterprise, and preserving activities within the boundaries of the model's objective, i.e. not exceeding the area of concern.

FIGURE 6.11: An example of business behaviour model surrounding an initiative for merging two organization units.



6.5 The Proposed Techniques Guiding the Employment

This section describes the proposed techniques, which use the extended meta-model to manage an enterprise ability to cope with change. They enable the maintenance of EA models by facilitating the data gathering of constantly changing business behaviour. The first subsection (6.5.1) discusses the new techniques' influence on the requirements management process of TOGAF. The second subsection (6.5.2) describes the four proposed techniques and their adaptation into the architectural development method (ADM) of TOGAF.

We start by defining the core constituents that represent the foundation of our techniques. Afterwards, we discuss the elements affecting stakeholders' choices as to which of the four techniques to employ. Then, we identify the different responsibilities that will be assigned to stakeholders taking part in EAM functions. We aim to integrate a set of constituents and practices into the ADM of TOGAF in order to establish an extension as a governing methodology in order to offer enterprises an approach adapted to their contexts. The four driving techniques will be described in subsection (6.5.2), they are named next:

- Assigning an indication to tasks for timely change generators that are linked to the corresponding stakeholders responsible for a particular division of the EA landscape; we call it **TimelyIT**
- Data gathering that supports automation with assessment of the models; we call it **AutoGA**
- Utilization of other information systems to identify timely change generators that are independent of EAM that prompt manual update of EA; we call it **independentCG**
- Utilization of internal timely change generators that are part of EAM that prompt manual update of EA models, an example of these events being the retirement-time of an initiative; we call it **innerCG**

The abstract difficulties of data maintenance within the context of EAM are outlined in Figure (6.2); they are caused by unqualified techniques and incomplete identification of roles. The constituents enabling our proposed techniques overcoming these difficulties will

be described after the following paragraph. These constituents are visualized in Figure (6.3). Essentially, an assessment technique is assigned to every data maintenance activity. In addition, clear responsibilities for every part of the landscape should be ensured at all times, especially the parts potentially affected by a transformation process. This can partially offer an assertion about the correctness of the presented representation. For instance, it will enable a stakeholder to examine at what time data is gathered from a specific source or at what time a specific stakeholder examined the actuality of an EA model constituent.

Here, we describe in short the **central constituents of the theoretical foundation of our structuring**. The main idea driving our work is to construct a methodology taking into account the context of enterprises applying it, while utilizing models/techniques that are parts of current approaches. The desired method would offer a structure for the identified features with the purpose of providing guided flexibility in order to reach cohesion among EAM processes and business behaviour in the enterprises ‘context’. The structure of this methodology will follow a similar structure to EA layers methods, see Chapter (2). The key constituents used in the methodology are described next:

First, **MethodParts** with the aim of building the methodology from smaller parts. Second, the **data maintenance technique** generates **processParts** and **productParts**. Third, **processParts** describes parts recursively utilized for a particular goal. Fourth, the **productParts** construction is maintained from the underlying meta-model explaining potential products. In particular, **processParts** explain the **data maintenance techniques** that construct **productParts**, that is to say, constructed or transformed EA model constituents.

However, in this methodology, the **processParts** are mainly isolated from context-related considerations. On the other hand, the produced **productParts** are essentially reflecting the context of the enterprise. For instance, the enterprise can decide on what automated activities should be employed. The **data maintenance technique** will produce **processParts** that will gather elements to be represented on respective EA models as a part of the EAM landscape. The models reflect on the context-specific essence of **productParts**. This is respective of the enterprise-context as choice is based on business context/behaviour, such as a particular EA model. This entails that **productParts** will not be fully identified within the methodology.

The key elements of contextual data gathering within EAM:

The following elements affect stakeholders' choices as to which of the four techniques to employ. These elements are elicited from the literature.

First element: data need/order There has to be a need for information from stakeholders constructing an EA model. It is key for stakeholders to base their orders on objective needs only (Wigand et al. (1997)). Orders should be omitted if no clear impact on a data maintenance activity is provided (Hanschke (2009)).

Second element: unit/group formation As discussed in the literature review chapters, the formation of groups within an enterprise (federated vs. centralized) has an impact on the activities carried out by these groups. This is clear particularly with transformation activities. Combination of the two formations has shown a constructive impact (Farwick et al. (2013); Fischer et al. (2007)).

Third element: organizational formation As in the previous element, the formation of the enterprise as a whole will affect the nature of activities (Buckl and Schweda (2011)). Communication among stakeholders is a clear implication of this element, such as in different geographical sites.

Fourth element: obtainable organized information sources This is driven by various information systems used in an enterprise, and how they offer different sources of data (Farwick et al. (2013)). This contextual element will have a direct implication on how a data maintenance method is built.

Fifth element: obtainable triggering events As information systems offer organized data sources, they are also able to generate events triggering transformation of the EA landscape (Farwick et al. (2012)).

Sixth element: high-level stakeholders' awareness and engagement High-level stakeholders need to approve the development of a new automated data maintenance methodology and its cost consequences. Therefore, the costs of an initiated method need to be examined.

Seventh element: the undervaluation of the expected financial benefits and exaggerated concern about security The integrity of business behaviour raises doubts among high-level stakeholders, as confidential information is exchanged. So, it might be advisable to eliminate such data sources from any initiated method.

Previous contextual elements are focal assessment criteria for constructing the enterprise-specific data maintenance method.

The core responsibilities for data gathering of business behaviour:

The practice affirms the necessity for somewhat minimal manual activities, as human participation is part of the actuality of any system. This is definitely applicable in EAM activities, as complete automation is not attainable. The following are descriptions of responsibilities that are essential to be explained for every method's implementation. Stakeholders are likely to be assigned several responsibilities:

First responsibility: data maintenance officer The stakeholder assigned to this responsibility should administer all aspects of data maintenance. The main task is to assign responsibilities to suitable stakeholders. If activities are not conducted within the specified timeframe, it is their duty to make decisions.

Second responsibility: data maintenance method designer The stakeholder assigned to this responsibility should manage combining process parts and supervising their implementation. It is their responsibility to analyse remarks on implementation and optimize future activities.

Third responsibility: source officer The stakeholder assigned to this responsibility should integrate external data sources with the landscape of EA, with consideration for any external triggering events.

Fourth responsibility: triggering-event officer The stakeholder assigned to this responsibility should carry out transformation from as-is EA-state to target EA-state generated by a triggering event. The main task is to understand the triggering-event and map this understanding on EA models.

Fifth responsibility: information officer The stakeholder assigned to this responsibility should be fully aware of all details of a specific part of the EA landscape. They should advise stakeholders if variations of representation exist, or in the case of duplication.

Sixth responsibility: EAM stakeholder The stakeholder assigned to this responsibility should be a recipient of EA models and taking actions/decisions based on these models, ranging from high-level management to architects and technical staff.

6.5.1 Influence on Requirements Management Process of TOGAF

This subsection discusses the affected aspects that can influence the adaptation of new techniques into the '**Requirements management process**' within the architectural development method (ADM) of TOGAF. Requirements management process is essential to every phase of ADM as it names, records, and communicates requirements with every one

of them, please see Section (2.2.3) for more details on ADM and its phases. We describe next the affected aspects in relation to our problem scope:

- Aspects of information gathering – The complex extent of activities within various layers of EA. –The identification of supporting information systems as a source for EA gathering activities. –Inability to identify reality changes that should have an impact on the EA landscape. –The incomplete set of obtained data that will result in a poor actuality of EA representation. –The lack of sources for information to reflect the reality of high-level layers. –Identification of expired and eliminated constituents. – These aspects are discussed in [Alegria and Vasconcelos \(2010\)](#); [Buschle et al. \(2012\)](#); [Farwick et al. \(2013, 2012\)](#); [Hauder et al. \(2012\)](#); [Holm et al. \(2014\)](#).
- Aspects of EA landscape progression – Transformation of EA models for the sake of data interchange. –Transformation conducted with the aim of mapping different information models, which are generated from diverse systems. –Transformation done to update EA models according to reality variations ‘purpose of actuality’. –Transformation to deal with redundancy of constituents due to different data sources. –Transformation conducted with the aim of integrating new data coming from external information systems. – These aspects are discussed in [Buckl et al. \(2011b\)](#); [Farwick et al. \(2013\)](#); [Hauder et al. \(2012\)](#); [Holm et al. \(2014\)](#).
- Aspects of management and business behaviour – The exaggerated concern of the technological infrastructure and its impact on the integrity of business. –The undervaluation of the expected financial benefits of such development. –The negative participation of data sources in the transformation of EA models. –The ambiguity of implications and responsibilities of modelling activities and automation. – These aspects are discussed in [Farwick et al. \(2013\)](#); [Hauder et al. \(2012\)](#).
- Aspects of the supporting tools – The constant alliance between the state of the EA landscape and reality with any external utilized information system. –The data gathering activities resulting in offering insignificant and irrelevant information being presented to stakeholders. –It is common to propose tools with no cohesion to the underlying meta-model. –The clearly missing tool support for data maintenance automation. – These aspects are discussed in [Farwick et al. \(2013\)](#); [Hauder et al. \(2012\)](#).

6.5.2 The Four Techniques of the Proposed Methodology

This subsection explains the details of each technique part. The responsibilities for the initiation and implementation of each technique are described.

A starting point is the realization that different parts of the EA landscape are lacking or partially lacking data gathering techniques to enable the representation of models reflecting the constant change of business behaviour. Therefore, our methodology will explain the main new data gathering techniques with descriptions of their process parts.

Essentially, each one of the four techniques will address data maintenance issues constrained within an identified part of five EAM layers. The extent of each one of the four techniques is outlined in Figures (6.12, 6.13, 6.14, 6.15). Process parts within techniques are applicable across different enterprises, with minimal adaptation. Nevertheless, the generated product parts are context-specific to the employing enterprise, as explained earlier in the theoretical foundation of our methodology.

The techniques were selected as they address the majority of data maintenance issues in all EAM layers. These four techniques are refined using a number of repetitive development cycles from diverse resources.

It should be clear that these techniques are not unchanging, as they should be optimized based on future studies. The following description of these techniques presents their goals, processes, responsibilities, and fitting contextual elements. In addition, we explain the construction preferences for all techniques to adapt the technique to the business behaviour/-context of an enterprise.

A detailed description and guidance of the first technique **TimelyIT** can be found in Table (6.1) and Figure (6.12). A detailed description and guidance of the second technique **AutoGA** can be found in Table (6.2) and Figure (6.13). A detailed description and guidance of the third technique **independentCG** can be found in Table (6.3) and Figure (6.14). A detailed description and guidance of the fourth technique **innerCG** can be found in Table (6.4) and Figure (6.15).

TABLE 6.1: Description of the first technique

Assigning an indication to tasks for timely change generators that are linked to the corresponding stakeholders liable for a particular division of the EA landscape; we call it TimelyIT	
Goal	- It can be applied on the EA landscape as a whole or partial information models. - It is parallel to common data maintenance processes, except in integrating them into repetitive and trackable automation construction. - InnerCG can be utilized for actuality issues, i.e. to trigger a reflective period.
Process parts	- It generates a triggering event to inform a stakeholder responsible for a data source that a data maintenance period has ended. - It allows a stakeholder to approve or not any model's transformation action. - If a stakeholder did not approve the action, and assigned it to another stakeholder, they will pass the responsibility with the action. - The passed responsibility varies from a straightforward search for an available document to conducting long meetings. - See Figure (6.12) for the flow composition of this technique.
Responsibility	- It clarifies the responsibilities needed within the scope of this technique. - The initiation of the process parts is carried out by the data maintenance officer who advises relative individuals to gather data required with coordination by the information officer. - Throughout the implementation, information officers are the only participating EAM stakeholders. - It declares whether there is any stakeholder that needs to be aware of the progress.
Business behaviour / context of use	- It has minimal initiation cost. - As in the most primitive and crucial technique, it is independent of all contextual elements.
Composition	- For the initiation, existing or additional EA model part should be determined by the associated responsibilities. - An instance of tasks, the assignment of actuality assessment for a particular area of interest should be completed for a selected EAM stakeholder. - Moreover, an important task is the determination of implementation periods responsible for anticipated transformation of models and actuality assessment checks.

FIGURE 6.12: Overview of the structure of the first proposed technique TimelyIT.

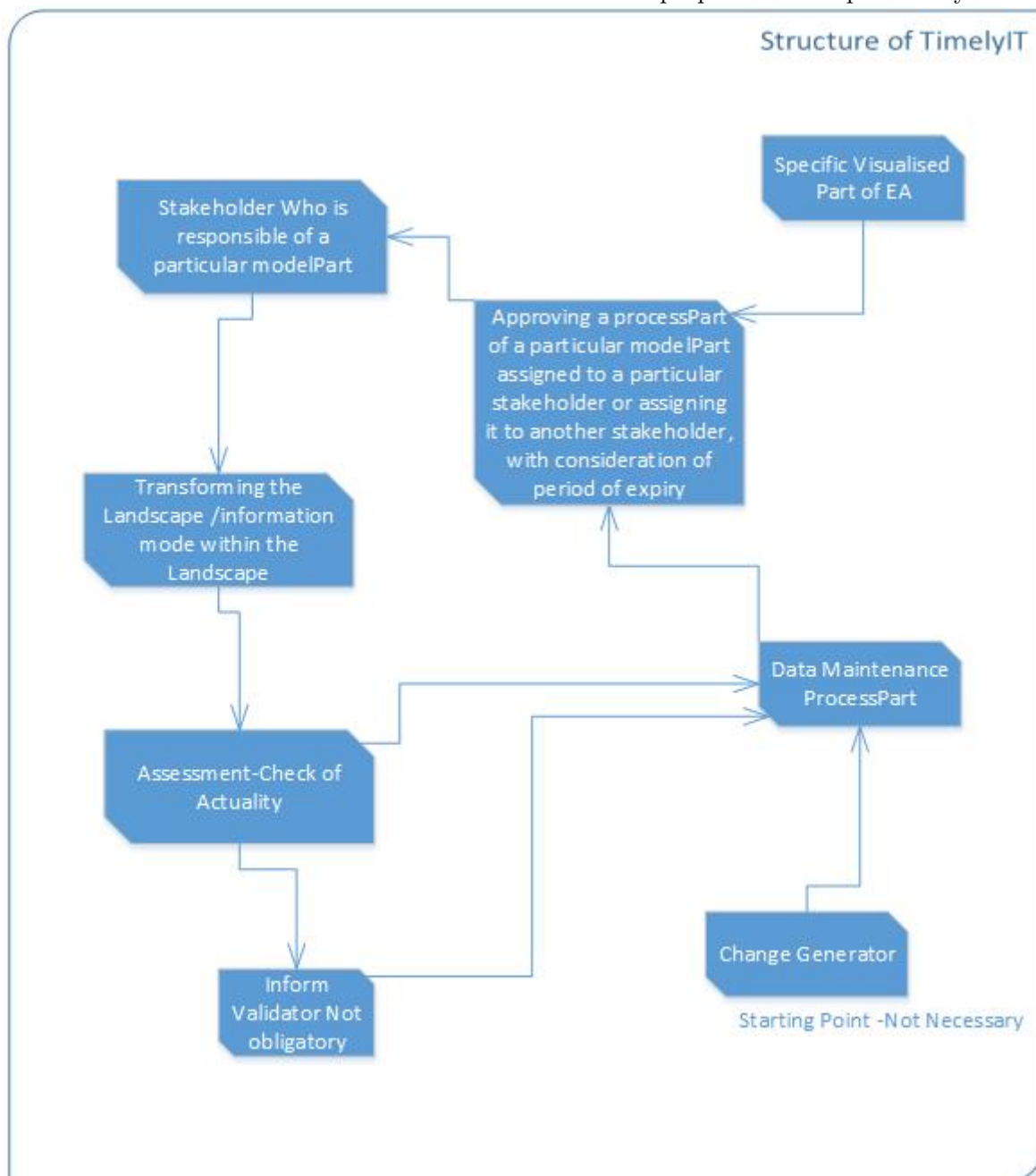


TABLE 6.2: Description of the second technique

Data gathering that supports automation with assessment of the models; we call it AutoGA	
Goal	- It aims to minimize manual endeavours for the particular parts of the landscape. - It supports the utilization of previously unexploited sources of information to be represented in the EA landscape.
Process parts	- Data gathering would start by determining the source and by determining cyclic gathering tasks. - This entails two initiation points, a cyclic gathering task, or a basic data gathering responsibility from a particular source. - The two points will eventually lead to integrating data into EA models, with a prerequisite task confirming whether automated integration is possible or minimal manual effort is required. - If no manual effort is required, then there is no need to assign an actuality assessment task. - If manual effort is required, a manual treatment task is assigned to a suitable stakeholder, although this task can involve a number of partial tasks, see Figure (6.13). - After completing manual intervention, non-compulsory actuality assessment task is offered. - See Figure (6.13) for detailed flow composition of the AutoGA technique.
Responsibility	- The source officer is in charge for initiation and the needed inclusion of data. - The information officer is in charge of aligning data from different sources. - Automation is the responsibility of all information officers as they are required to implement the actuality assessment task.
Business behaviour / context of use	- It is employed to offer applicable information to be represented in the EA landscape, by the existence of relative sources of information. - If employed, it balances the costs in the course of external information inclusion and constant manual efforts.
Composition	- For the initiation, all relevant sources have to be accessible. - A reflective representation has to be offered that integrates data from diverse sources into a context-related EA landscape. - Periods responsible for anticipated transformation of models have to be identified for every source of information including assigning responsibilities for manual data gathering and manual actuality assessment checks.

FIGURE 6.13: Overview of the structure of the second proposed technique AutoGA.

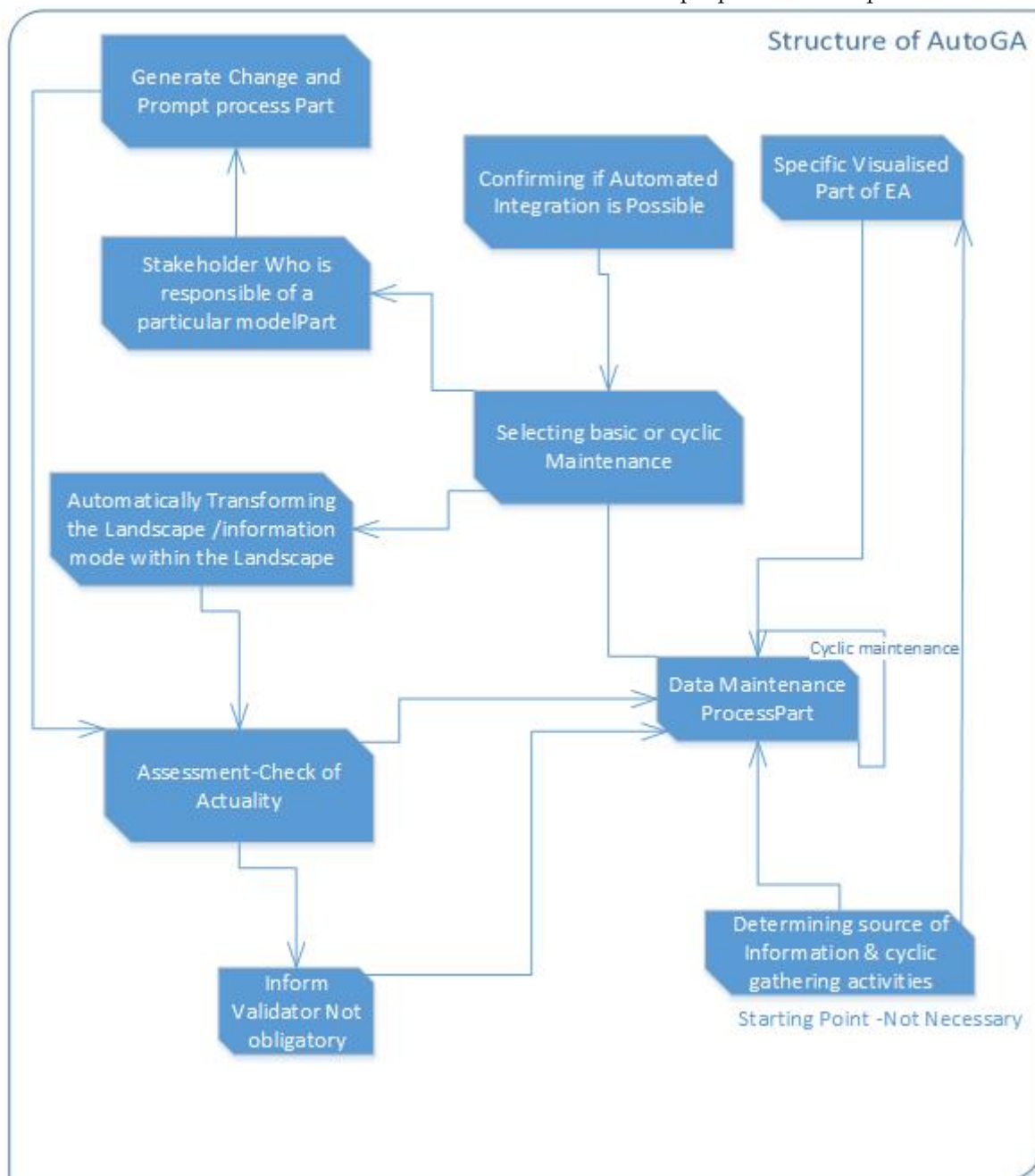


TABLE 6.3: Description of the third technique

Utilization of other information systems to identify timely change generators that are independent of EAM that prompt manual update of EA; we call it independentCG	
Goal	- It aims to use triggering events from other information systems to aid instant updates of the EA landscape that would not be possible with original sources of information employed in the previous technique. - It additionally aids the alliance between data maintenance processes and business processes in the enterprise. -It can be utilized to generate cyclic actuality checks in a manner similar to the first technique.
Process parts	- It expresses how to deal with a triggering event, including early notice to relevant EA stakeholders. - Then, it allocates a fitting stakeholder to execute the responsibilities, which are relevant to the information source and the event source. - The assignment of the task is supplemented with context-related data. - This stakeholder is entitled to assign a task of additional assessment-check to another stakeholder. - This stakeholder is also entitled to prevent any further events from the same source or ignoring this particular event while permitting future ones from the same source; the actuality assessment task can be included too. - See Figure (6.14) for the detailed flow composition of this technique.
Responsibility	- For the composition, the data maintenance officer is in charge of naming the tasks connected to the triggering event, in addition to discussing them with the information officers, who are responsible for the triggering event source. - Information officers can be asked to determine the significance of a particular event, while relative EAM stakeholders are briefed about the transformation.
Business behaviour / context of use	- It is employed once there are real causes of triggering events that can be utilized to generate transformation of the EA landscape, regardless of the type or source of change.
Composition	- The responsibilities and their assigned stakeholders should be identified with recognition of the type of the triggering event. - Identification of the periods allocated for extracting the triggering event and for applying the resulting transformation to the EA landscape.

FIGURE 6.14: Overview of the structure of the third proposed technique independentCG.

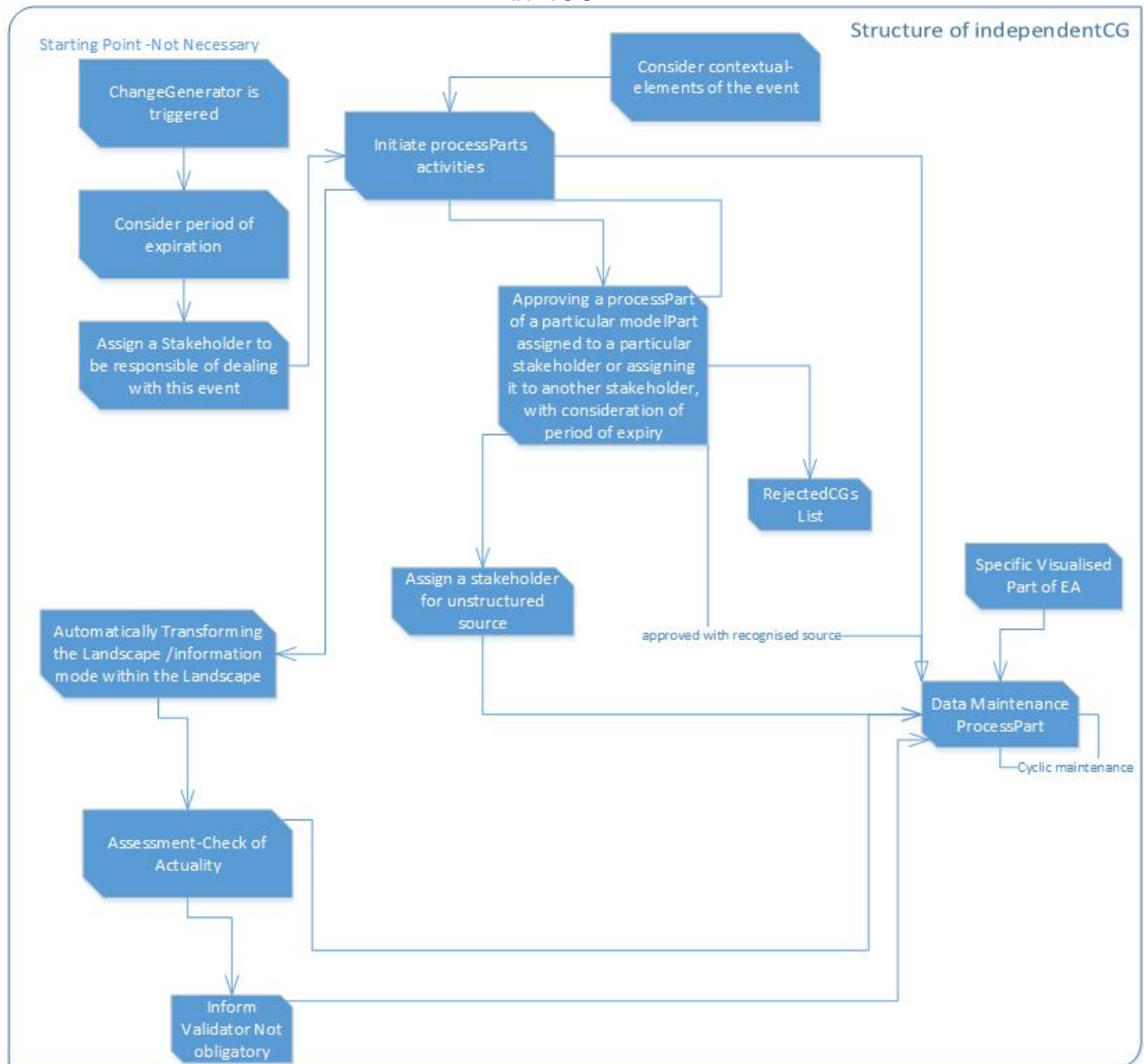
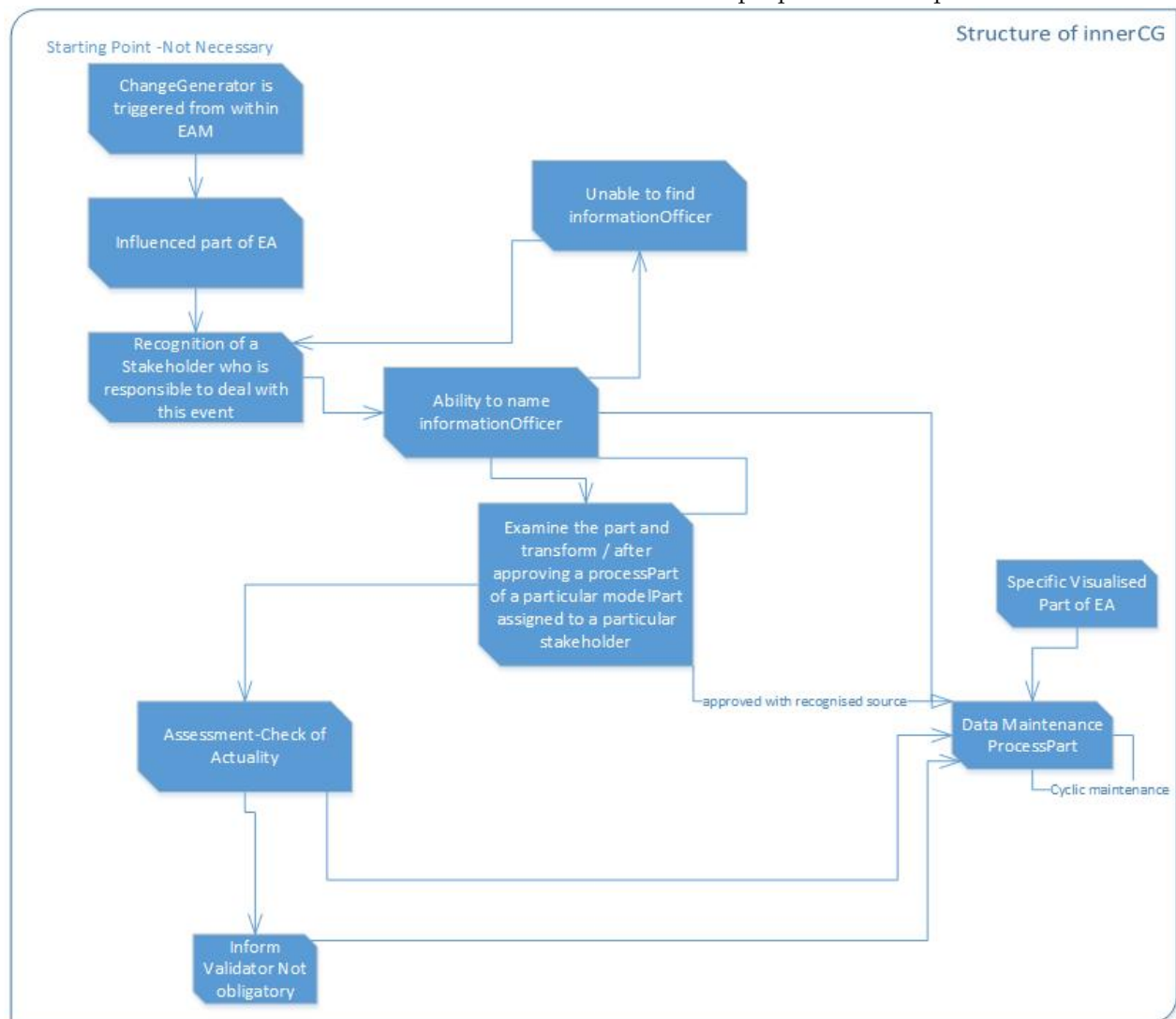


TABLE 6.4: Description of the fourth technique

Utilization of internal timely change generators that are part of EAM that prompt manual update of EA models; an example of these events is the retirement time of an initiative; we call it innerCG	
Goal	- It aims to enhance the instant actualization of the EAM landscape. - It asks relevant EAM stakeholders to carry out assessment checks of the actuality of their representation; this is done following certain assigned periods or following meeting predefined conditions.
Process parts	- It names the information officer in charge of the influenced part of representation. - If the influenced area exceeds one part, a data maintenance officer is assigned to the task. - After that, either one of them will have to carry out a manual assessment check of the actuality of representation. - In the case of transformation, additional tasks will be assigned to approve the mapping. - See Figure (6.15) for the detailed flow composition of this technique.
Responsibility	- The data maintenance officer organizes the dialogue between information officers and the relevant EAM stakeholders. - It should be noted that information officers fulfil most of this techniques' responsibilities. - The data maintenance officer has to be fully involved in case of a wider influence. - A period is assigned for different types of triggering events, clarifying their expiration.
Business behaviour / context of use	- It is mainly useful in the case of a particular part of EA models that has no recognized controlled source of information (AutoGA). - And it can be used if it has no triggering events (independentCG). - This is highly significant as it is can be used with high-level business activities that match the previous conditions.
Composition	- First, different types of triggering events should be represented. - Second, a period is assigned for different types of triggering events, clarifying their expiration. - Alternatively, the data maintenance officer needs to identify all the predefined conditions of the triggering events. - They also need to identify the intended parts of the EA models and associated responsibilities.

FIGURE 6.15: Overview of the structure of the fourth proposed technique innerCG.



6.5.2.1 Guiding the Contextual Adaptation of the Four Techniques

In this part, we explain the utilized guidance to adapt the proposed methodology as a context-related methodology. This is done with consideration of the previously described contextual elements and four techniques. The four described techniques can be combined to form a data maintenance approach with careful consideration to the changing business behaviour/contextual elements in order to offer enterprises a context-related method.

To begin with, contextual elements of an enterprise have to be examined. The overall construction of the enterprise should be clarified, including clarifying group organization, data sources, and triggering-events. Additionally, the requirement level of data for every type of the needs of represented components have to be examined, along with the needs

relating to the actuality level of models.

Depending on these contextual elements, the four techniques can be composed to the requirements of the enterprise as explained next. Repeatedly, process parts are tailored to these requirements, responsibilities are allocated, and triggering-events sources are structured. As the data maintenance method is executed, assessment checks of EA models actuality are performed. This experience and feedback is then utilized to re-tailor and optimize the methodology.

The following guidance explains the successive phases that are employed to produce the necessary knowledge, to enable assessments on what technique to use with which information and triggering-events sources:

Requirements

All requirements have to be fulfilled to assess the applicability of the methodology. The identified requirements include the availability of a model representing the area of interest in addition to supporting data maintenance activities with the proper tool.

First stage: naming needs of representations' actuality

EAM stakeholders examine the actuality needs of each represented component. It includes identifying the end of assessments' period, and naming needs to conclude any process.

Second stage: naming information and triggering-events

It begins with naming all information officers and triggering-events officers, with identification of the sources of information. It includes naming type, actuality needs, abstraction-level, layer, and conditions of the gathered information.

Third stage: combining selected techniques

It begins with integrating previously named details about information and triggering-events with chosen techniques in order to collect data from the listed details. It assigns identified responsibilities to particular stakeholders to defined sources. It selects the proper technique based on contextual elements. In addition, the cost for the execution is stated here.

Fourth stage: concluding assessment

The resulting combinations of the previous stages have to be prioritized and finalized. The methodology has to select the automated sources for valuable components with low execution cost and little data-protection threat as well as high anticipated actuality. It is advised to avoid sources with particularly low abstraction level due to expected high costs. A number of technique selections are performed during the execution of the methodology. Every single technique can be utilized a number of times with different sources. We do not offer rigid guidelines for adaptation because contextual elements play a big part in decisions.

After integrating appropriate techniques with respective sources, the methodology as a whole should be gathered in the manner of implementable process parts. This involves the use of all sub-processes of all selected techniques in a chosen tool, for example the ‘process-based EA-repository prototype’. Process parts are not executed simultaneously; different process parts trigger other different process parts.

The new role of adaptation officer is in charge of organizing and gathering the contextual data in addition to examining the needs of other roles. The adaptation officer discusses their responsibilities with other EAM stakeholders, such as the significance of sources, costs, and composition tasks.

Summary of the EAM Framework Chapter with Guidance to the Remaining Chapters

We started with a reflection on our research questions and how they have guided the development of our solution, see Section (6.1). Afterwards, we identified the main constituents and practices we used in our solution, see Section (6.2). Then, we described the structure and constituents of our extended meta-model and how the new constituents were categorised, see Section (6.3). We then highlighted our efforts to facilitate modelling with joint understanding of business behaviour among diverse stakeholders, see Section (6.4). After that, we proposed four techniques to compliment the architectural development method (ADM) of TOGAF, see Section (6.5).

The following Chapter (7) presents an examination of our solution based on the employment's functioning and participants' remarks, followed by a self criticism of our practices. Moreover, we offer a critical reflection involving limitations, discussion points, and conflicts associated with the used research methodology. Chapter (8) concludes our thesis with learned lessons and future work.

Chapter 7

Evaluation

The solution was evaluated by means of an action case study within a semi-governmental enterprise called Al-Elm. Such development as a whole requires critical reflection answering potential conflicts. We use the term solution to refer to our proposed methodology with the extended meta-model.

In the first section, we present the evaluation of our solution. We link the evaluation to the identified requirements that have guided the development of our proposed methodology and extended meta-model. In addition, we relate and compare the outcomes from our action research evaluation to the literature, see Section (7.1).

This chapter also offers a critical reflection on our action research involving limitations (7.2), discussion points (7.3), and analysis associated with the use of action research as our research methodology (7.4).

7.1 Evaluation of Our Proposed Methodology and Extended Meta-Model

This section depicts the participating stakeholders' evaluation of the solution in relation to every aspect affected by our proposed methodology and extended meta-model. The evaluation obtains its validity from our reliance on action research as the driving methodology of our research. The evaluation focuses on the actual employment of our solution in practice. Therefore, we present the evaluation of the stakeholders who participated in the actual employment of our solution.

This section offers a concise comparison of the stakeholders' evaluation of enterprise architecture management (EAM) practices with and without employing our solution as will be illustrated in the comparison figures. Their evaluation is more valuable in reality than routine evaluation methods of theoretical proposals. Our solution was employed in Al-Elm, where 17 business initiatives of EAM have tested its employment.

Our main methods to obtain their evaluation were in the form of a questionnaire and interviews, as explained in our action research methods in Chapter (3). We designed our questionnaire in a way that allow participating stakeholders to add their own remarks if they have additional observations, see Appendix (A).

We link the evaluation to the identified requirements that have guided the development of our proposed methodology and extended meta-model, see Section (5.3) in Chapter (5). In addition, we analyse the stakeholders remarks gathered during the employment of our solution. In addition, we will describe how we benefited from the employment and remarks to improve and redefine the solution. Furthermore, throughout this section we relate the outcomes from our action research evaluation to the literature.

Our solution was utilized in parallel EAM practices for the implementation of 17 initiatives. The research and development unit (RDU) at Al-Elm coordinated all these tasks. These 17 initiatives were implemented first using standard EAM practices in Al-Elm. We observed the utilization and examined the produced documentation from these practices. We then discussed relevant issues with associated stakeholders. Regarding the identified requirements, stakeholders were questioned throughout the action case study about their assessment of how EAM practices satisfy these requirements. After the employment of our solution on 17 initiatives, the same discussion and enquiries were conducted to grasp their assessment of the solutions' employment. Based on the literature, we designed the

questionnaire to investigate the key required outcomes from these EAM practices.

As the employment of our solution was conducted by the RDU, our participation has focused on the design, definition, and redesign of the solution. During the meetings, the RDU and respective architects drove the integration of our solution to EAM. As the enterprise was utilizing a number of tools, the proposed techniques are restricted to the capabilities of these tools. In addition, as our solution was only employed for a limited period of time, all assumptions must consider the time limit.

It should be realized that the gathered data is affected by the tool support existing in the enterprise. In particular, this is apparent in the allocation of responsibilities and information correctness.

The overall remarks highlight the capacity of our solution to counter identified points of emphasis. The proposed structure of the different techniques is praised, as it can identify actual contextual needs, i.e. which sources and techniques.

This section offers additional insights analysed from the stakeholders' feedback. The feedback has revealed various important insights in relation to our solution. This part will first present the remarks and discussion points of stakeholders in regard to the offered techniques and their utilization.

The outcomes illustrate the analysis of the satisfaction of corresponding stakeholders in relation to the requirements of business behaviour management in Section (7.1.1), maintenance of enterprise architecture (EA) models in Section (7.1.2), and shared stakeholders' understanding in Section (7.1.3). Afterwards, we evaluate the impact of employing our solution on the EAM practices within Al-Elm, see Section (7.1.4).

7.1.1 Evaluation of Business Behaviour Management

The extraction of requirements of business behaviour management for improved practices is derived from the literature. The description of these requirements can be found in Tables (5.1, 5.2) in Chapter (5). The outcomes illustrate the analysis of the satisfaction of corresponding stakeholders in relation to these requirements, see Figures (7.1, 7.2, 7.3).

There are a number of outcomes obtained from their assessment. The utilization of our solution has slightly reduced the flexibility. This can be caused merely by the introduction of new constituents. Another potential cause is the composite structure of change generators. A noticeable improvement is clear in the clarity of responsibilities. It is expected that patterns' evolution is still the same, as our solution did not address this issue. The initiatives' impact on future EA states has become more visible; this is mainly due to included time knowledge. The observable development of initiatives has improved. However, this is unjustifiable as we did not address the visualization of initiatives' progress. This can be the result of stakeholders being affected by the purpose of the research. This is discussed in the weaknesses in Section (7.4).

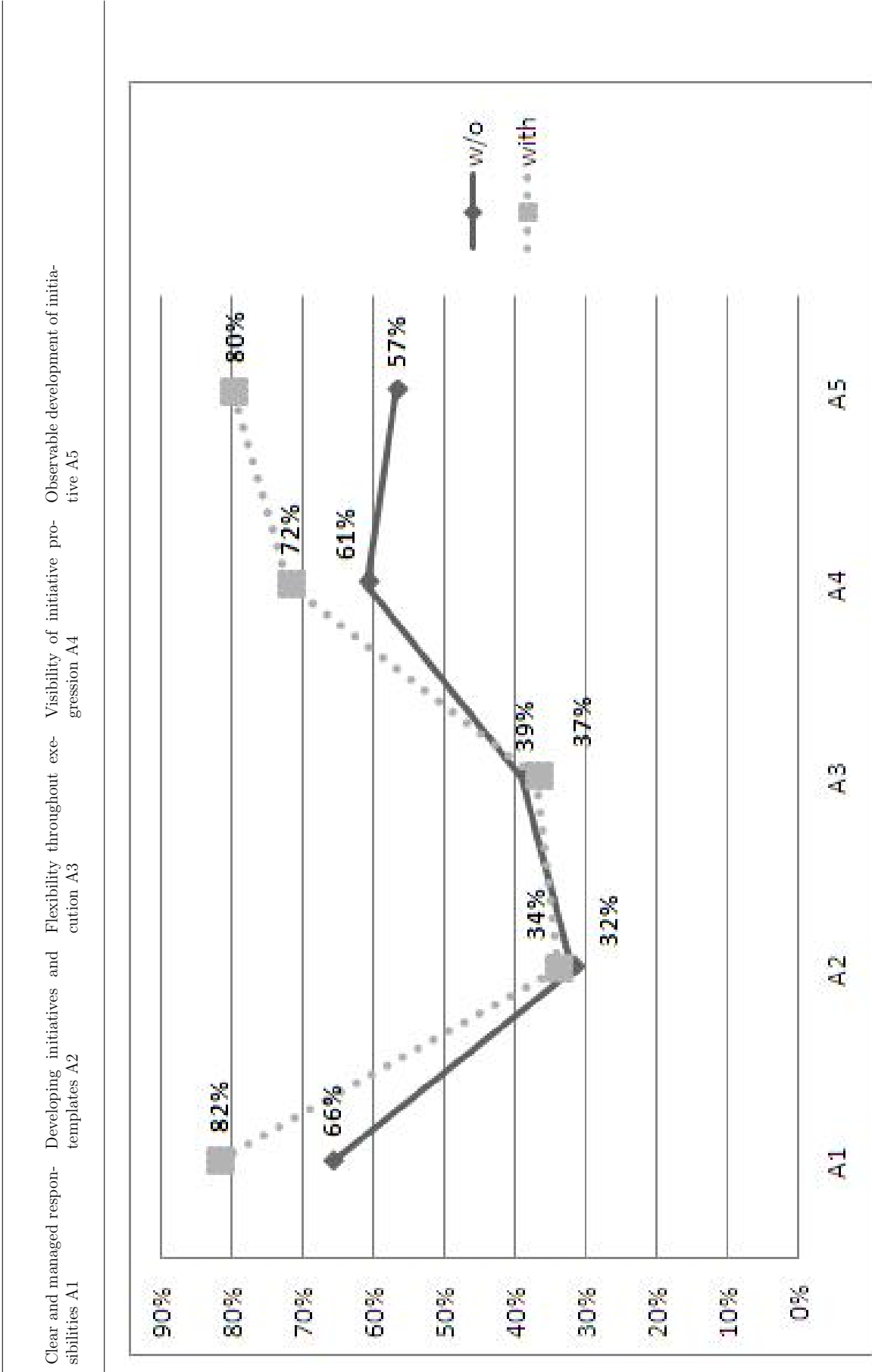
In relation to the clear and managed responsibilities, questioned stakeholders were able to view all responsibilities and roles associated with an initiative they interact with. This is important for the ease of collaboration to improve on the current practices assessed in Herrmann and Kurz (2011); Kurz (2013); Swenson (2010).

In relation to improved practices of developing initiatives and patterns, we aimed to offer nonstop joint understanding for current and potential initiatives. We extended on the practices of the architectural development method (ADM) of the open group architecture framework (TOGAF) (The Open Group (2009b)) by offering guidelines for shared understanding of mental model of architects. This participated partially to the achievement of this requirement but not yet completely fulfilled as highlighted in Herrmann and Kurz (2011); Motahari-Nezhad and Bartolini (2011); Schonenberg et al. (2008); Swenson (2010).

In relation to flexibility throughout execution, we ensured that throughout the cycle of an initiative, the roles and responsibilities should not be mandatory to offer flexibility throughout the implementation. Our skip and redo roles were contained in the task, in addition to the execution roles. This was in contrary to usual workflow management as suggested by Herrmann and Kurz (2011); Kurz (2013); Swenson (2010); Van der Aalst et al. (2003). However, the questioned stakeholders indicated a reduced flexibility, this was expected owing to the new constituents they need to be familiar with.

In relation to the visibility of initiative progression, stakeholders need to realize the progress of an initiative was enabled by ticking completed tasks and identifying the remaining ones. This is a basic way to address this requirement in comparison to the complicated practices offered in [Herrmann and Kurz \(2011\)](#); [Swenson \(2010\)](#). In relation to observable development of tasks, we represented all open tasks and their challenges.

FIGURE 7.1: Requirements for business behaviour management –Part 1 –Analysis of the satisfaction of corresponding stakeholders in relation to these requirements.



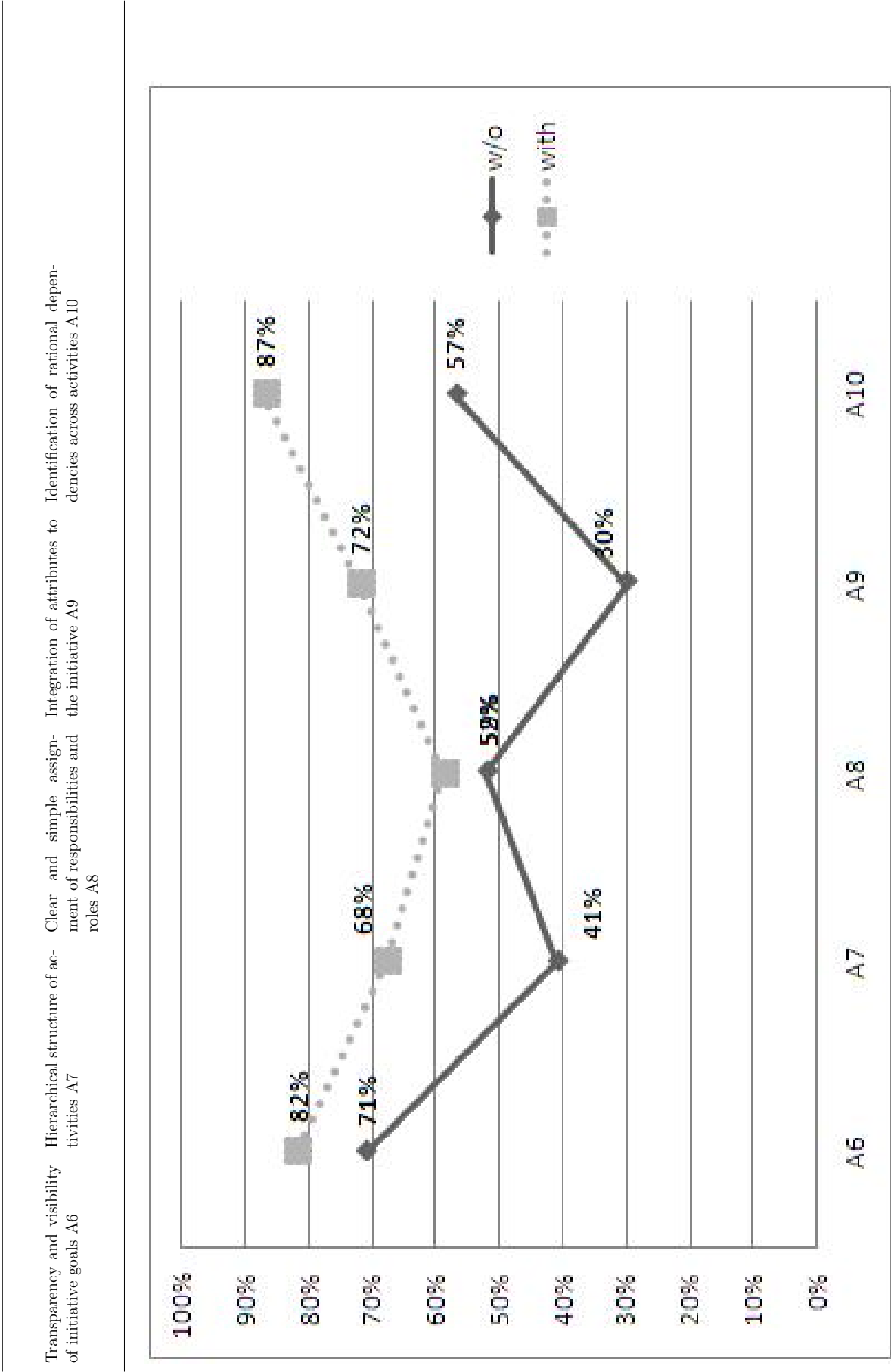
In addition, the simplicity of assignments has not improved. This needs to be addressed in future development. The visibility of initiatives' goals seems to be a missing aspect of our solution. Stakeholders have indicated their approval of the proposed structure and its impact on initiatives. The integration of business behaviour attributes is admired. The new representation of dependencies between constituents has raised the satisfaction of identification of rational dependencies.

Furthermore, the availability of guidelines is considered not sufficient in the new solution. Stakeholders have advised developing extensive textual description. Flexibility of enabling new roles and stakeholders at run-time has improved. The solution is considered more comprehensible and flexible for business stakeholders. Representation of time is one of the most praised aspects of the solution. This is represented with the attributes of 'temporarily' in the meta-model. The new solution has clearly enabled high-level management to trigger changes at run-time and see the implications of their decisions.

In relation to transparency and visibility of initiative goals, we communicated to declare the expected final outcome from an initiative. In Relation to the hierarchical structure of activities, we offered hierarchical structuring of tasks in contrast to process networks in order to enable architects to easily include additional tasks. This suggests the identification of tasks in advance followed by incremental improvement. Our solution matched the outcomes achieved in [Herrmann and Kurz \(2011\)](#); [Swenson \(2010\)](#).

In relation to the clear and simple assignment of responsibilities and roles, we started the process by assigning stakeholders to an initiative with their associated responsibilities. This improves on the work assessed in [Van der Aalst et al. \(2003\)](#). In relation to integration of attributes to the initiative, we shifted the practices for maintenance of EA models to document-centric nature rather than customary activity-centric workflow management. The relevant approaches are assessed in [Herrmann and Kurz \(2011\)](#); [Kurz \(2013\)](#); [Swenson \(2010\)](#); [Van der Aalst et al. \(2003\)](#).

FIGURE 7.2: Requirements for business behaviour management –Part 2 –Analysis of the satisfaction of corresponding stakeholders in relation to these requirements.



In relation to the identification of rational dependencies across activities, we facilitated the definition of dependencies between tasks to be implemented at a certain time in contrast to dependencies that are not relative to what time they are implemented. A number of tasks can have pre-conditions that need to be accomplished prior to their implementation. This was highly praised by questioned stakeholders in comparison to current practices ([Kurz \(2013\)](#); [Swenson \(2010\)](#)).

In relation to ensuring comprehensible and flexible practices for business stakeholders, the high-level management stakeholders with no EAM or modelling knowledge have failed to comprehend some of our proposed techniques. They preferred the minimal practices of ADM as explained in [Kurz \(2013\)](#); [Swenson \(2010\)](#).

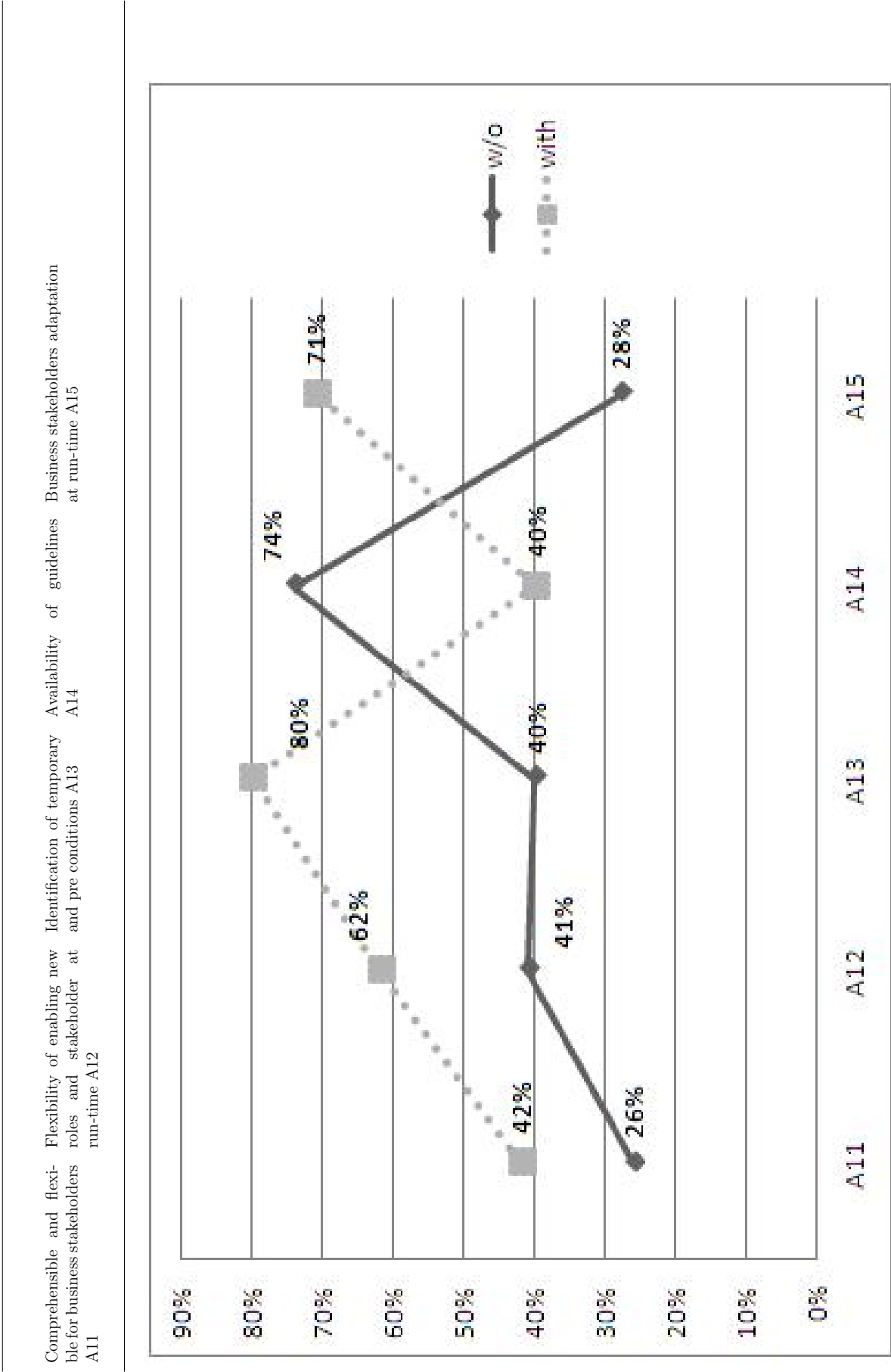
All participants approved our solution's ability to provide architects with the means to support the success of new initiatives. They emphasized the importance of its capability to offer adaptation at run-time in addition to its capacity to represent additional roles and valued knowledge of the initiative. These features are essential for the practical execution of EAM processes.

In relation to flexibility of enabling new roles and new assigned stakeholder at run-time, architects responsible for the execution of a particular initiative were able to assign additional stakeholders to the initiative if required at run-time. This is a important strength of our solution in comparison to current practices ([Herrmann and Kurz \(2011\)](#)). In relation to identification of temporary and pre conditions, our proposed meta-classes enclose attributes representing tasks' pre-conditions that need to be accomplished prior to the implementation of the tasks.

In relation to availability of guidelines, we proposed guidelines to model what already exist in the mental model of architects. They were formed in a way that supports shared understanding of business behaviour between involved stakeholders. This was praised as an advantage of our solution. Any partial fulfilment of this requirement is considered important ([Motahari-Nezhad and Bartolini \(2011\)](#); [Schonenberg et al. \(2008\)](#)).

The guidelines and proposed techniques drive the employment. In the literature, there are a number of proposed wide-range languages with proposed constituents that can be utilized for EAM practices. However, due the lack of guidelines managing the utilization, these languages are not practically employed. At the same time, our guidelines have to be extensively described in a textual manner to enhance applicability. This also supports the desired standardization prospective.

FIGURE 7.3: Requirements for business behaviour management –Part 3 –Analysis of the satisfaction of corresponding stakeholders in relation to these requirements.



7.1.2 Evaluation of Maintenance of EA Models

The extraction of requirements for maintenance of EA models is derived from the literature. The requirements are derived from a number of EAM frameworks that we examined to select a number of their constituents to be part of our solution, see Chapter (6). The outcomes illustrate the analysis of the satisfaction of corresponding stakeholders in relation to these requirements, see Figures (7.4, 7.5).

Their assessment indicates several findings. A positive feedback is the benefit of improved multiple states identification. A negative feedback indicated that the meta-model did not change the EAM's ability to produce descriptions of future states before modelling. As our solution did not address the challenge of a visual roadmap, it is indicated that our extended meta-model might affect this issue negatively. A clear improvement is noted in relation to target EA states' adaptability. In comparison with current approaches, the planning for current landscape encouraged sketching the representation of future landscape states. This was not facilitated by existing approaches ([GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Jonkers et al. \(2005\)](#); [Matthes et al. \(2008\)](#); [Van der Torre et al. \(2006\)](#)).

Our solution has shown no improvement in regard to distinctive views of different concerns. It is true that we did not offer a means for this cause. However, this confirms previous remarks stating the need for better visualization capacity in the form of viewpoint models rather than just the information models offered in our solution. In comparison with current approaches, we also lacked the modelling capability to project views for every identified concern ([Frank \(2002\)](#); [Niemann \(2006\)](#); [Van der Torre et al. \(2006\)](#)). It should be easier to link these views for the addressed concern.

In relation to the projection of drafts of future landscapes, we need to offer a comprehensive explanation of future application landscape from a logical perspective, i.e. architecture blueprint. A number of approaches provides satisfactory means to achieve that in [Frank \(2002\)](#); [Jonkers et al. \(2005\)](#); [Niemann \(2006\)](#).

In relation to the clarity of application landscape roadmap, the new development of TOGAF has a clear documentation on how to develop EA states in sequence of time to demonstrate evolution from current to future application landscape. This requirement is discussed in [Frank \(2002\)](#); [GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Jonkers et al. \(2005\)](#); [Niemann \(2006\)](#); [Van der Torre et al. \(2006\)](#).

Our solution lacked the ability to link components of business mental models to components of technology. A particular technique is needed to improve business stakeholders adaptability to future states. The employment of our solution shows that the transition from current to target landscape should be incremental with the involvement of stakeholders during all stages of transition. This is discussed thoroughly in [Frank \(2002\)](#); [Garg et al. \(2006\)](#); [Matthes et al. \(2008\)](#); [Van der Torre et al. \(2006\)](#).

Moreover, there was a clearly improved assessment of the five core features guiding the introduction of proposed constituents, in relation to improved practices of maintenance of EA models. The stakeholders' feedback has indicated clear improvements of enabling the trilogy of associations, visualization of business support providers, inference of target landscapes, landscape variation, and traceability of stakeholders' decisions.

Our proposed capacity to represent trilogy of associations has improved on current practices. We enclose a trilogy of associations to facilitate examination of existing and prospective business behaviour. The information model clarified the approve-associations T7 among ProcessParts T1, EAMInfrastructure T2, and Elements T4. This practice offers additional capacity in comparison with current EAM frameworks' practices ([Frank \(2002\)](#); [Garg et al. \(2006\)](#); [GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Jonkers et al. \(2005\)](#); [Niemann \(2006\)](#)).

In relation to visualization of future approval of processParts, our meta-model offers the capacity to sketch a visualization of future approval of processParts T1 and the source of approval (modelPartRole T3), with the aim of easing future states planning with no need to identify execution specifications of the processApproval T6. We were able to combine practices from different EAM frameworks ([Garg et al. \(2006\)](#); [GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Matthes et al. \(2008\)](#); [Van der Torre et al. \(2006\)](#)).

In relation to inference of target EA states, our meta-model offers the capacity to enable the inference of target EA states from the current initiatives' activities T5. Therefore, it can facilitate the progression from the existing to target and prospect processApproval T6. This practice exists in EAMPC but not part of ADM of TOGAF and is discussed comparatively in literature ([Frank \(2002\)](#); [Garg et al. \(2006\)](#); [Jonkers et al. \(2005\)](#); [Matthes et al. \(2008\)](#)).

In relation to target EA states alternatives, our meta-model offers the capacity to support the formation of target EA states alternatives built on different implications of initiatives' activities T5. This practice was attempted in a number of approaches ([Frank \(2002\)](#); [Jonkers et al. \(2005\)](#); [Niemann \(2006\)](#)).

In relation to traceability of high-level stakeholders' decisions, the ability to save and organize knowledge from former EA states while associating them to time is significant. This can facilitate the traceability of stakeholders' decisions. The value of this knowledge is greater if it is supplemented by details of the motives and responsibilities of these decisions. This is an attempt improving on current approaches ([Frank \(2002\)](#); [Garg et al. \(2006\)](#); [GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Jonkers et al. \(2005\)](#)).

This part will present how we benefited from the remarks of stakeholders in regard to the **extended meta-model**, see Figure (6.4). We will describe the employment of their feedback to improve and refine the solution:

We were encouraged to further extend our meta-model and initiate a particular primitive constituent and its relationships to the initiatives' tasks. Figure (6.4) illustrates the meta-model integrating these notions. Within the proposed meta-model, any initiative that is influenced by dynamic factors can originate its `periodOfExpiration` from the start/end points of time relating to influential connected initiatives. An instance of the implication of the dynamic factors can be seen in the associations between representations of changes. Another example is the allocation of initiatives' dependencies between influenced events within the EA model.

However, choosing the utilization of a common UML inheritance notation will not enable stakeholders from different backgrounds to comprehend the model clearly. This is because there are a large number of instances expected to be derived from this initiative with dependency. Therefore, we initiate another stereotype called (`initiatedepend`) that can be allocated to a class to signify that it is a subclass of initiative with dependency. This can be done to produce a less complicated and more concise model.

The meta-model represented in Figure (6.4) addresses the previous requirement to a satisfying level. Target EA landscape states alternatives/variations can be originated at any time, built on different (time knowledge) details of a particular initiative. However, these states are not preserved, since the model does not include a constituent for maintaining diverse initiatives and states varieties. This should not be considered an important weakness, as initiative variations are known to be employed in the dialogue of other fields, such as for project portfolio management.

Moreover, there is a need for a number of further constituents in order to enable the preservation of diverse variations, and also to preserve more complicated diverse timelines for the initiatives in ongoing application landscape planning. This would cause practical concerns, as architects will not favour such complications, and stakeholders will not be able to comprehend such models. In addition, the resulting complexity in generating model instances may not balance the advantages gained from this supplementary mechanism of target planning.

A number of improvements can be derived from their feedback. One of the improvements is to document guidelines for role and responsibility assignments. In addition, we

were encouraged to document description of this employment of the solution, in a standard manner utilized by the RDU at Al-Elm. They have praised the capability of assigning specific tasks within the mechanism to identifiable stakeholders.

We were persuaded at different stages to ensure the simplicity of the proposed meta-model, as the different backgrounds of stakeholders affected their comprehension. In addition, any complex structure will affect any potential utilization by tools and EAM practices. Furthermore, the terminology changed at different stages to be in line with TOGAF and previous practices inside the organization. The prospect of offering a suitable user interface will be able to overcome any complexity concerns. A suitable user-interface will facilitate stakeholders' modelling practices.

A number of remarks have highlighted the importance of our extended meta-model comprising processApproval T6 and approveAssociation T7, as it will ease the creation of target states due to its clear association with modelPartRoles T3, Initiatives T5, and processParts T1. Without the previous structure, the representation of initiatives' time dependencies via inheriting might not be applicable, unless additional constituents are included. The latter will raise the complexities of information models, so it will not be practical.

The ability to represent changes in initiatives at run-time and consequently improved representation of the application landscape is a key feature. The majority of participating stakeholders affirmed that our approach would improve stakeholders' ability to represent their changing initiatives in, while all highly experienced EAM stakeholders agreed on its ability to boost the success of representing the planned application landscape in enterprises.

During the interviews, a few stakeholders praised our assessment checks that ensure the completeness of all key steps of the intended initiative and not to neglect any step, while some were using primitive checklists. A few stakeholder suggested that a review method would be crucial to continuously examine changes on initiatives' goals. There was special praise for the new meta-information which enables the prioritization of tasks. Examples include the time knowledge and management of change generators.

A number of remarks were directed at the extraction of diverse initiatives' requirements, security measurements, and a mechanism for collective documentation of EAM. A few enhancements were mentioned but are beyond the nature of this solution, such as compliance issues and regulatory audits.

Additional meta-information was suggested for future improvements, involving new pre-defined attribute types. A few recommendations were suggested for the success of new meta-information, as they have to be easily found in the solution. Another suggestion is offering additional visualization capacity especially when it comes to evaluating the progress of an initiative.

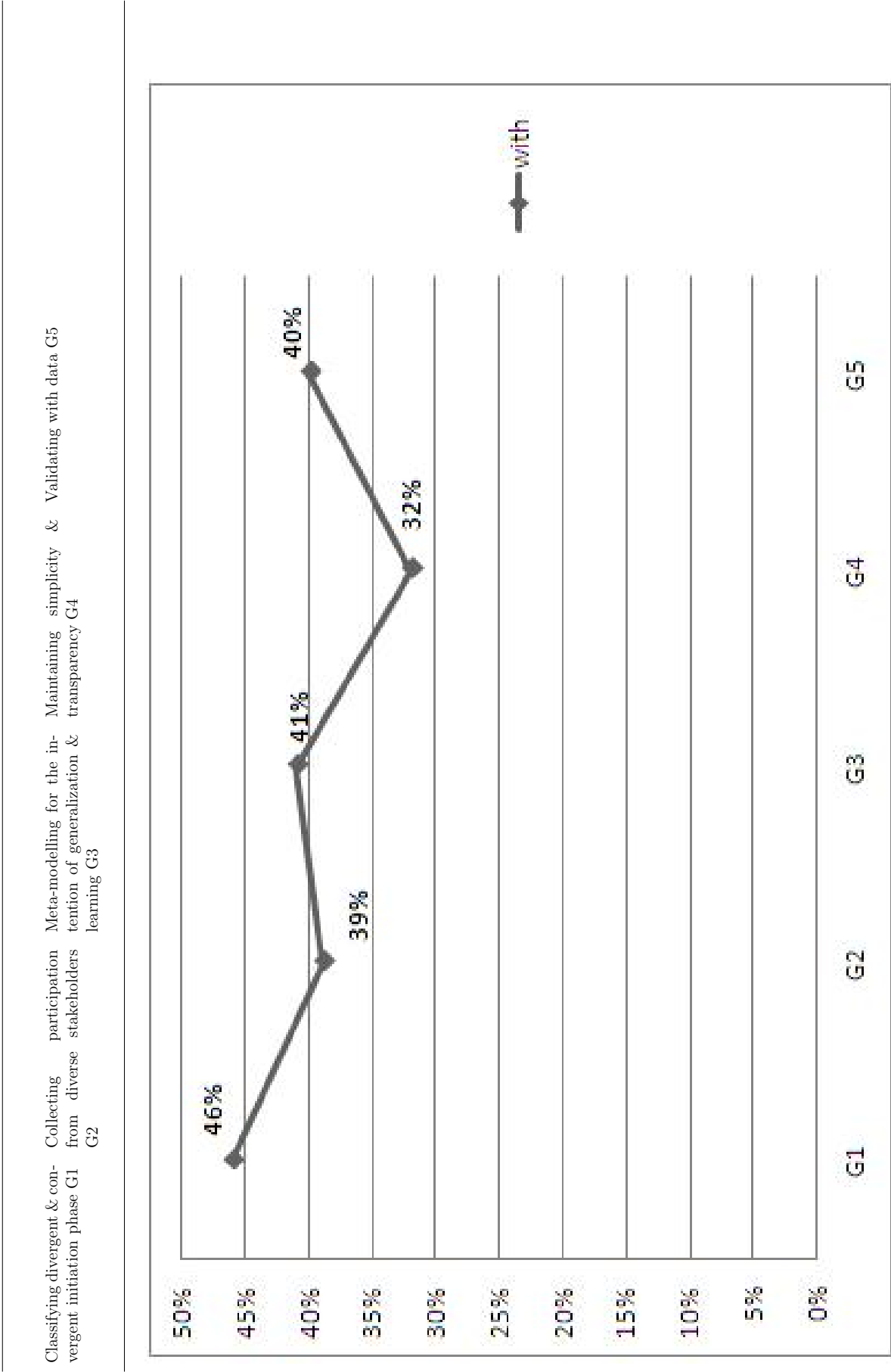
We have dedicated some efforts in accordance with the literature to ensure that we only include constituents and practices that are simple and feasible, and which are in line with the purpose and nature of our solution. A few remarks have suggested the exploration for additional principles and concepts from areas isolated from EAM and landscape representation. However, we opted to leave this added possibility for future research.

7.1.3 Evaluation of Modelling of Shared Stakeholders' Understanding

The endeavours of designing a solution facilitating new information models encompasses identifiable actions, their order of implementation, a meta-model, and a governing method. This is a challenging mission. The motivation to facilitate an advantage overcoming this challenge has led us to extracting a number of design guidelines for collective thinking of different stakeholders relative to a particular initiative. These guidelines enable the joint understanding of contextual factors constrained in the minds of stakeholders.

The definitions of these guidelines can be found in in Chapter (6), see Section (6.4.2). Since no concrete mechanism for collective thinking was in place before our action case study, we questioned the stakeholders after the utilization only. Following the employment, discussion and enquiries were conducted to grasp their assessment of the solutions' employment. The outcomes illustrate the analysis of the satisfaction of corresponding stakeholders in relation to these guidelines, see Figures (7.6, 7.7).

FIGURE 7.6: Design guidelines for business behaviour dynamics modelling –Part 1 –Analysis of the satisfaction of corresponding stakeholders in relation to the actuality of the employment of these guidelines.



The outcomes show encouraging results to a certain degree. However, stakeholders had some criticisms. The utilization of causal loop diagrams (CLD) was an area of concern. This is due to the required familiarity of CLD from stakeholders of different backgrounds. A few stakeholders suggested the utilization of the proposed guidelines to guide the documentation and distribution of business behaviour. This conflicts with our general feature of designing the guidelines so as to reach shared understanding of diverse mental models. Another criticism is the increased workload for every participant. The objective of these guidelines was praised by all stakeholders.

Figure (7.7) presents the assessment of stakeholders for a particular example (initiative) described in Subsection (6.4.3). They particularly examined the resulting dynamic s for this particular initiative and how it covers contextual factors for this particular initiative. The hypotheses as described in the solution chapter involves implications on productivities, landscape maintenance, progression of EAM function, minimizing expenses of the enterprise, and preserving activities within the boundaries of the model's objective.

This part first presents the remarks of stakeholders in regard to the **offered guidelines and their employment via causal loop diagrams**. Then, we describe how we benefited from the employment and remarks to improve and refine the guidelines:

In light of the proposed guidelines for modelling business behaviour surrounding initiatives modelling, the following presents the key utilized evaluation settings as well as some stakeholders' insights. The action case study has ensured the verification of the models as well as evaluating their correctness to act as a communication instrument.

The questionnaire was designed to cover a number of evaluation parts, involving stakeholders' general standpoint on standardization, evaluation of the hypotheses, and an evaluation of the modelling notations. At critical points, conversation style ([Goguen and Linde \(1993\)](#)) discussions took place to obtain greater knowledge. We tried to analyse stakeholders' insights from their personal understanding. We offered personalized cases for clarification.

Most of the participating stakeholders praised the solution's ability to incorporate informal guidelines. They highlighted the ability to incorporate and grasp the informal guidelines and know-how documented in enterprises in order to offer awareness of contextual factors and their impact on EA.

Stakeholders have valued our proposed guidelines for joint understanding. However, they have suggested the integration of modelling rather than utilizing causal loop diagrams.

The following list introduces the key stakeholders' insights:

- The stakeholders showed sufficient comprehension of the terms and notations used. In addition, they mapped successfully the proposed hypotheses to their own understanding, although we offered oral clarification to ease understanding of the solution components. On a few occasions, stakeholders reflected on symbols inaccurately. Stakeholders were capable of responding accurately to enquiries on dynamic hypotheses, constructive and destructive implications, in addition to transitive implications.
- All participating stakeholders referred to their own experience and perceptions for understanding the offered mechanism and models, with discussions on particular cases regarding objectives of elements and roles.
- The remarks on the produced causal loop diagrams were generally positive, and they supported their goal of improved joint understanding. A number of further causal implications were mentioned, including improved productivity as a result of

automation and further standardization, an instance where there is no need for extra time for training new employees. The estimation of implication levels differ among diverse stakeholders, mainly due to their own perspectives, and responsibilities.

- On the other hand, participants declared low effect of other aspects. It can be noticed that a given stakeholder appreciates aspects associated with their direct roles and responsibilities, that is to say their mental model of the EAM framework. Similar observations can be deduced regarding the required time-cost to comprehend a particular model.
- In a few cases, transformation in stakeholders' answers was noticed before and after offering the solution/model; all of these cases associated with participants with low experience. For instance, when questioned about the positive influence of the 'example initiative', see Figure (6.11), prior to offering the mechanism, they named a set of positives. Afterwards, when questioned after offering the mechanism, they named the highlighted additional positives, in the proposed model, without further examination.
- Stakeholders' first reaction when introduced to the solution is overstated in relation to the complexity of the solution. On the other hand, they showed understanding of its appropriateness after linking the already proposed components with the integrated EAM framework. The benefits highlight easier communication between varied stakeholders specifically high-level managements.
- It can be observed from the remarks of the stakeholders that a few features of causal loop diagrams are not applicable to EAM, such as kind and delay.
- These guidelines offer a foundation for future development of a method tailored for EAM which is based on a form of modelling similar to causal loop diagrams. Additional means to enable strategic decision representation can be valuable. It is mentioned that these guidelines have the potential to be utilized in other contexts, for example elicitation of requirements.
- It should be noted that these insights are limited by the scope of the action case study.

Reflection on the Proposed Guidelines:

Building on the findings of our action case study, we were able to derive and extend the offered group of guidelines which were extracted from the literature. The examination and analysis of the findings and stakeholders' perceptions derive the following additional guidelines:

Responsibilities should be illustrated unambiguously: Visualization models should clearly comprise particular responsibilities for particular components of EA models, by utilizing means such as signs or colours. This is significant for clarity and simplicity, as it can identify potential conflicts.

Utilized terms should be unified: Building on the remarks of the stakeholders, this is important for facilitating communication between stakeholders of different backgrounds, utilizing means such as communicated glossaries. The utilized terms should be comprehended identically by stakeholders.

Minimize utilized constituents for simplicity and usability: As a reflection on our solution, the feedback indicates the need to reduce the extent of modelling components when presenting the models to prospective stakeholders. This is important as visualization models should contain fewer components. For instance, a number of symbols have to be removed from model visualizations in order to improve communication and presentation such as, delay, direction, and kind symbols. Thus, minimal elements need to be utilized rather than offering an inclusive model.

7.1.4 Evaluation of the Employment

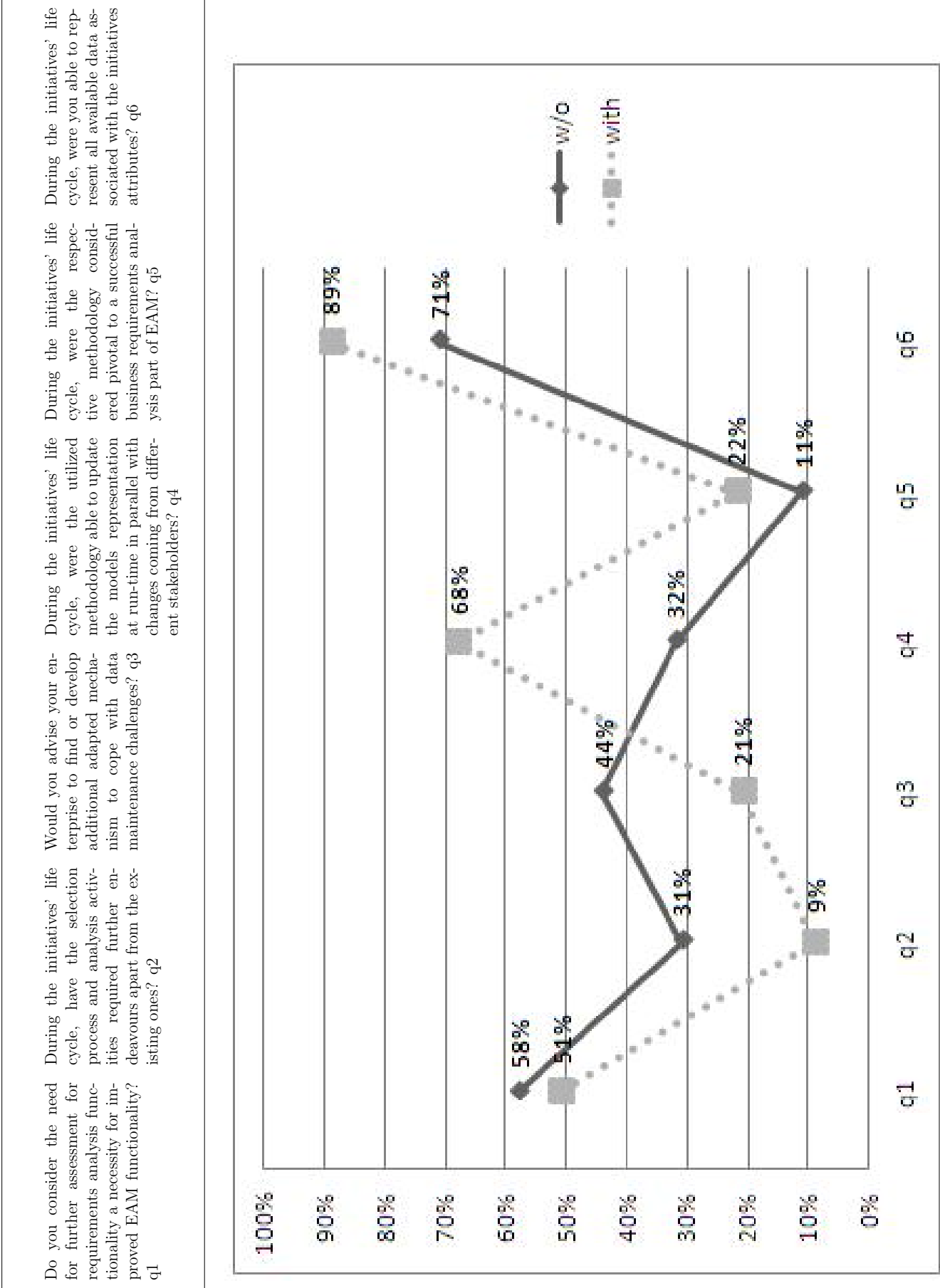
This section evaluates the impact of employing our solution on the EAM practices within Al-Elm. This section questions the capacity offered by our extended meta-model and to what degree were the offered techniques able to use the new constituents as intended.

The extraction of these questions is derived from the literature and can be considered as a contribution of our action research. The description of these remaining issues can be found in Chapter (5), Tables (5.3, 5.4, 5.5). Many discussion points in Chapter (6) explains the terms used in the questions. Stakeholders were questioned throughout the action case study about their assessment of how EAM practices satisfy the expected outcomes. After the employment of our solution on 17 initiatives, the same discussion and enquiries were conducted to grasp their assessment of the solutions' employment. The outcomes illustrate the analysis of the satisfaction of corresponding stakeholders in relation to the realization of these outcomes, see Figures (7.8, 7.9, 7.10, 7.11).

In relation to the instant update to models representation, we enabled time constraints for modifications of models representation in order to improve the desired dynamics. This is an improvement in comparison to current approaches (Frank (2002); Jonkers et al. (2005); Spinellis (2001)). In relation to counter attributes identification, this is still a concern that need to be addressed to add value to the process completion as highlighted in literature (GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert (2005); Plazaola et al. (2008)).

In relation to constant harmony with input from stakeholders, we enabled triggering the update process at run-time in parallel with changes coming from different stakeholders is in question. Current practices concerning the update of models representation is an area of continuing development (Buckl et al. (2010b); Frank (2002); Plazaola et al. (2008); Spinellis (2001)). In relation to the additional endeavours for the selection process and analysis activities, the need for further endeavours apart from the existing ones is still a concern that we did not succeed to fulfil (Frank (2002); Matulevičius and Heymans (2007); Moody et al. (2009); Spinellis (2001)).

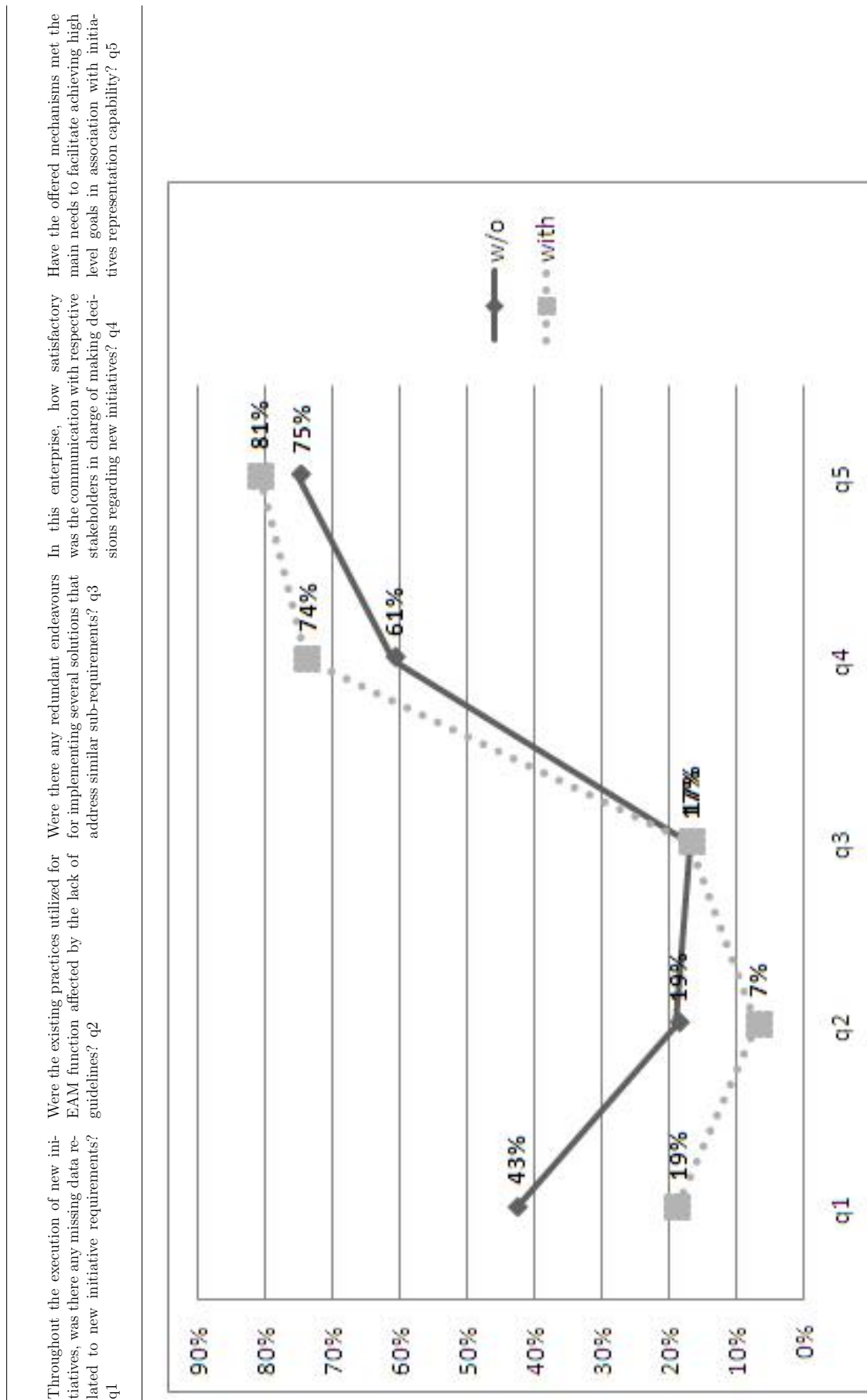
FIGURE 7.8: Assessment of the solutions’ employment part 1.



In relation to inclusive representation of data associated to the initiative attributes, stakeholders were able to represent all utilized data that is associated with initiatives' attributes. The representation on the basis of the success of a single initiative with disregard to future initiatives conflicts with the purpose of EAM. This is a progress in comparison with current state ([Buckl et al. \(2010b\)](#); [Frank \(2002\)](#); [Matulevičius and Heymans \(2007\)](#); [Moody et al. \(2009\)](#); [Plazaola et al. \(2008\)](#); [Spinellis \(2001\)](#)). In relation to successful business requirements analysis, there is still a needed improvement for the alignment between mechanisms that are considered pivotal to a successful business requirements analysis and their incorporation ([Buckl et al. \(2010b\)](#); [GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Jonkers et al. \(2005\)](#); [Plazaola et al. \(2008\)](#)).

In relation to elimination of redundant endeavours, several existing solutions can be partially implemented to address similar sub-requirements ([Frank \(2002\)](#); [Jonkers et al. \(2005\)](#); [Matulevičius and Heymans \(2007\)](#); [Moody et al. \(2009\)](#)). In our solution, elimination of such redundancy was enabled by representing time-knowledge of triggering events of changing business behaviour. In relation to sufficient communication with associated stakeholders, we enabled the communication between stakeholders in charge of making decisions regarding new initiatives. This is an important feature of our solution as it offers a new practice ([Buckl et al. \(2010b\)](#); [Frank \(2002\)](#); [GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#)).

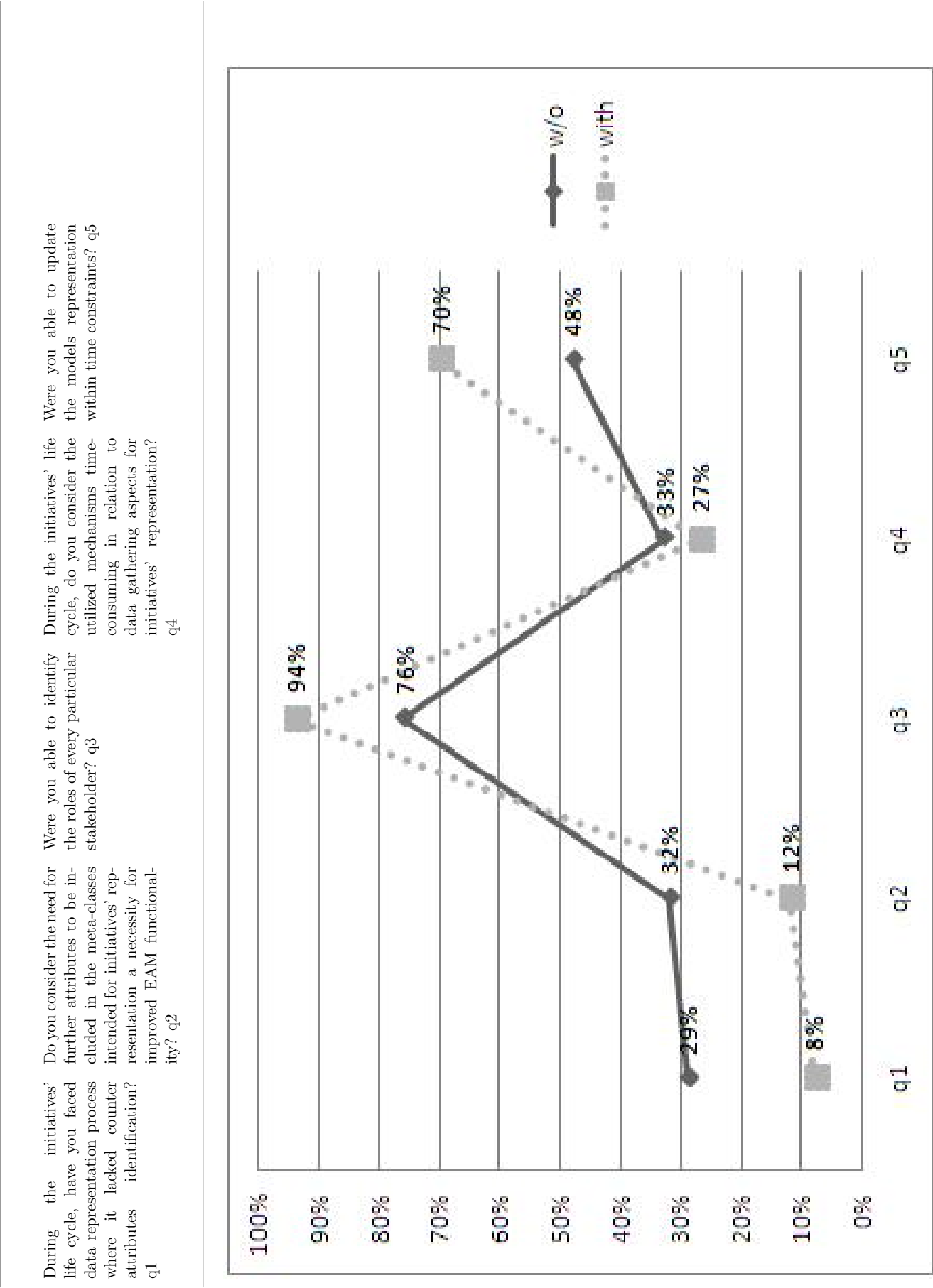
FIGURE 7.9: Assessment of the solutions' employment part 2.



In relation to actuality of representation from stakeholders' perspective, various stakeholders have highlighted the need for further attributes to be included in the meta-classes, which are intended for initiatives' representation. The crucial issue is to analyse if the inclusion of such attributes is a necessity for improved EAM functionality. This is still a concern ([Frank \(2002\)](#); [GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Jonkers et al. \(2005\)](#); [Matulevičius and Heymans \(2007\)](#); [Spinellis \(2001\)](#)). We facilitated the representation of shared mental models that exist in various stakeholders' minds. This was very important to the success of any initiative.

In relation to business stakeholders' adaptation at run-time, high-level management stakeholders were able to make decisions on future tasks of initiatives by means of comprehensive representation. In relation to structured data gathering, we were informed of a time-consuming concern in relation to the data gathering aspect for initiatives' representation. Another point of concern is the value of structured techniques in comparison with manual guidelines ([Buckl et al. \(2010b\)](#); [Frank \(2002\)](#); [GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert \(2005\)](#); [Plazaola et al. \(2008\)](#)).

FIGURE 7.10: Assessment of the solutions’ employment part 3.

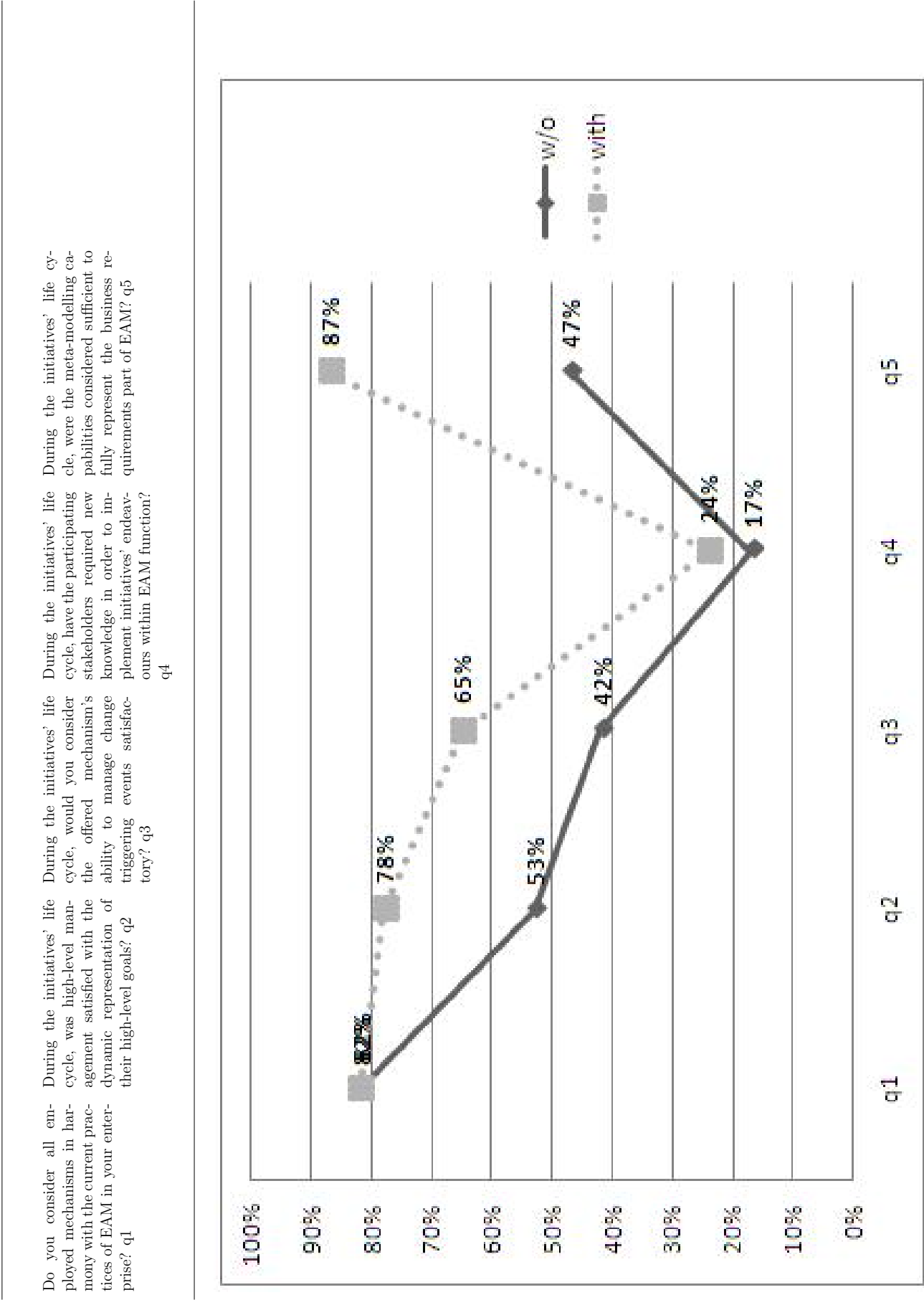


In relation to same set of EAM knowledge, participating stakeholders required no new knowledge in order to implement initiatives endeavours within EAM function. Otherwise, the solution will face challenges in practice if an additional set of knowledge is required. This offered simplicity and ease of integration for our solution (Buckl et al. (2010b); Frank (2002)). In relation to the capacity of underlying meta-model, the focus here was on meta-modelling capabilities considered sufficient to fully represent the identified requirements of EAM.

In relation to satisfactory and dynamic representation of high-level goals, we put forward the employment of system dynamics to add to current methods, see Chapter (6). These guidelines facilitated modelling stakeholders' behaviour and their decision implications. This modelling composes embedded application landscape progression principles that do not exist in formal guidelines but in the minds of diverse stakeholders. In order to achieve this, we extract a few guidelines from the literature for collective modelling of communicated understanding of business behaviour.

In relation to management of triggering events, we first studied whether the offered methodology to manage change triggering events is satisfactory. This was followed by the identification of these events. Afterwards, the representation of these events was improved. The implication of these events on structured maintenance aspects is considered too. This is a clear improvement on current practices (Buckl et al. (2010b); Frank (2002); GI-Edition Lecture Notes in Informatics By Braun, Christian and Winter, Robert (2005); Jonkers et al. (2005)).

FIGURE 7.11: Assessment of the solutions' employment part 4.



The following discusses the concerns analysed from the outcomes of the evaluation:

The challenges associated with the aspects of business behaviour management are fulfilled up to a satisfactory level. There are a number of concerns. First, the realization might be affected by the number of activities required to identify information sources and link them. Second, the incomplete set of obtained data is still a concern. Third, future work has to be conducted to find a way to ensure complete identification of expired and eliminated constituents, as our work could not fulfil this challenge.

The challenges associated with the aspects of EA landscape progression are fulfilled up to a satisfactory level. However, there are also a number of concerns here. First, a number of stakeholders have highlighted the need to develop a proper user interface to facilitate the transformation conducted among EA models for the sake of data interchange. Second, our TimleyIT was able to manually enable stakeholders to map different models produced from different frameworks. Third, identification constraints are valuable for eliminating redundancy of constituents with the need of additional activities. Fourth, we were not able to optimize the transformation conducted with the aim of integrating new data coming from external information systems as manual activities were still needed. This is a future research point.

The challenges associated with the aspects of shared understanding of business behaviour are fulfilled up to a satisfactory level. However, here too there are a number of concerns. First, a major concern is the high management alert to integrity; this was beyond the scope of our research and is still a challenge. Second, the support from RDU has enabled us to overcome the undervaluation of the expected financial benefits of such a development. Third, the introduction of partofAuthority answers the challenge of participation of data sources in the transformation of EA models. Fourth, the new constituents of the meta-model reduce the ambiguity of implications and responsibilities.

The challenges associated with the aspects of supporting tools are not fulfilled in this research. However, there are a number of potential optimization points. First, the correlation between the state of the EA landscape and the external utilized information system seems to be hard and not practical. Second, a number of the identified challenges of supporting tools appear to be very advanced to recommend investigating them. Third, it is still the same regarding missing tool support for constant maintenance of EA models apart from some early and unsatisfactory attempts.

All in all, we can argue that our methodology is one of a small number of attempts with similar concerns. In addition, it exceeds any of the current attempts by offering guiding

techniques. Moreover, our methodology offers a foundation facilitating the practices of our proposed techniques in the manner of an extended meta-model comprising additional constituents. We acknowledge the need for tool support to complement our methodology comprising useful user interfaces.

We acknowledge the need for more practical implementation in more than one enterprise as in our action case study in order to further prove the utility of the methodology. The findings from this study verify the usefulness of this methodology in this enterprise only, as the dynamic business behaviour changes between enterprises which could lead to varying outcomes. In addition, the lack of parallel methodology as shown in the related work limits the comparability of solution features. Yet, our extensive examination of the literature shows that our structural approach answers most of the requirements.

Our action case study has illustrated the usefulness in reality of our solution to put together a practical approach to complement current practices. Future investigation is encouraged in respect to tool support and further practical evaluation. Another prospect is the mapping between the information gathered in practice and presentation refinement of the EAM landscape. We aim to explore enhancements to all aspects of the methodology and any potential tool support, with the possibility of additional techniques.

7.2 Limitations of the Proposed Solution

Our proposed methodology acts as an extended development on top of current EAM functions of TOGAF. This methodology has addressed previously identified challenges. The nature of the proposed methodology is in harmony with EAM practices. Here are some of the identified limitations of our proposed methodology:

Regional exclusiveness: The nature of the region of the action case study may have a direct impact of the practices within EAM frameworks. These features involve higher spending, cultural implications, and inexperienced personnel. A thorough observation and learning were initiated to grasp existing techniques and how they divert from standard practices and what is exclusive for the organization and the region.

Endorsement of the study: The endorsement of the research and development unit (RDU) of the enterprise where the action case study took place is a main strength for this study, as it enabled us to examine our solution in practice in addition to giving us access to enterprises and practitioners. However, the fact that our study is endorsed might have an impact on the participating stakeholders' input. For instance, they might be hesitant when it comes to their feedback or limit and constrain their real opinions.

Participants' partiality: We clearly questioned the participants in relation to their identified difficulties; it should be noted that this may have caused partiality. An additional analysis shows that there are some restrictions when it comes to extracting data from participants related to correlations; therefore supplementary research needs to be undertaken to prove this to be true or not.

The potential resemblances to newly introduced enterprises' functions should continuously be examined. Our research has taken into consideration the specifications of EAM frameworks. In addition, our solution is designed in a way that harmonizes with the design of various architecture layers and processes. One of the key recommendations for future work would be to illustrate resemblances to different enterprises functions in which association to high-level goals can come into view.

The most significant limitation in EAM practices appears to be the lack of clear model practices or methods for handling dynamism in EAM. This had a direct impact on the design of the solution because we had to extract, validate, and integrate attributes for the meta-model as a base for the solution. This was addressed by two main means. The first was to study best practices of EAM as extension blocks, and the second was to propose a

structure for presenting the solution.

Bearing in mind the offered outcomes, we disagree with current practices by lowering the reliance on manual EAM efforts to cope with dynamism as they need to be thoroughly investigated. Our solution are designed to be a step closer to automation. However, our solution are interacting with many other manual EAM practices, this lowers the desired outcomes.

Some stakeholders' remarks suggest and encourage enhancements exceeding the scope of our research, see Section (7.1). Yet a number of these remarks serve partially the objective of our research. Thus, it has to be considered a limitation not being able to address these suggested aspects.

Collaboration of stakeholders: Throughout the course of the action case study, achieving the support and collaboration of individuals was a concern. This limitation might have affected a number of activities of the action case study. This was obvious during the tasks of the early stage of our action case study, which were described in Chapter (5).

Governmental exclusiveness: Our action case study was privileged to be able to investigate a number of large enterprises employing some sort of EAM framework, see Chapter (4). However, these enterprises all fell into one type of enterprise which is semi-governmental enterprises. Therefore, this may have a direct implication for the outcomes of the study, because business-oriented enterprises were not unambiguously covered in this study. One of the limitations is that governmental practices differ from private enterprise practices, so it is harder for outcomes to be generalized. Private businesses might offer a different insight to the study. In contrast, our strength is the ability to study how a growing, developing country like Saudi Arabia is dealing with new technologies.

One limitation is the potential contradiction between our terms' definitions and future editions of different EAM frameworks. This can be overcome by producing detailed explanation and mapping between our terms and principles along with relative practices of dominant EAM frameworks.

The satisfactory outcomes from our implementation in relation to realizing the desired attributes cannot provide a productive and practical solution on their own, as they need in principle their own user interfaces; this is due to the ongoing development of EAM frameworks. The design of our research has taken the issue into consideration. This issue is generally true as a principle, whereas our solution is built as a flexible extension to be

added on top of TOGAF.

Nature of action case studies: A key limitation to the research is the possibility that the feedback and findings might be affected by the nature of the action research methodology. We tried to face this limitation by putting in effort with the team to choose participating stakeholders rather than just accepting volunteers, but still this might have an impact. An example is more clear when a stakeholder facing difficulties with dynamism reads the publicity of our study, then comes forward to be part of the study.

7.3 Discussion

There are a number of discussion points emerging from the employment of our solution:

The context of our case supports the accomplishment of our goals as it is suitable for an action case study, where the goal is to investigate novel conditions. This is a sign of there being no need to manage behavioural conditions or variables (Yin (2013)). It is additionally appropriate for the investigation of previously unstudied environments, such as enterprises in the Gulf countries in our case. Nevertheless, multiple-case designs are advised to describe the steps of theory building. The first stage of the study was accomplished in our action case study, see Chapter (4). In Benbasat and Zmud (1999), it is recommended to offer multiple-case designs to enable broad-cases examination and development of theory.

We consider our approach as a methodology focusing on qualitative analysis (Yin (2013)), while gathering information using participants' reflection/observation, extensive interviews, and systematic investigation. First, we were aiming to comprehend the examined problem. Second, we were seeking to ask insightful questions in order to understand the depth of the enterprise's behaviour. After that, the resulting solution is presented for potential generalization as well as further expansion and examination. Therefore, regardless of the outcomes of the latter objective, we have fulfilled the earlier two objectives.

It was a necessity to employ an action case study as the means of methodology for this particular problem. The recurring problems associated with dynamism within EAM affirms the remark that researchers know reasonably little about the variables of the observed behaviour until they acquire an in-depth knowledge of the context in which the behaviour exists and then try to understand it from the viewpoint of practitioners (Van Maanen et al.

(1982)). Similarly, contextual awareness and standpoint goals are doubtful to be realized where researchers lack observation and involvement with the research setting, which is an important guideline for such qualitative research.

Investigating the development of a case is rewarding using the feedback to drive the evolution of an action. This statement is discussed in several publications. The main conflict arises from the confirmation of the credibility of the findings. Confirming this has been challenged in the literature to show actuality from the viewpoint of positivistic philosophy. The three main aspects realizing the credibility of the findings are generalization, reliability, and validity. Every one of the three aspects receives criticism but confirms their credibility. The discussion of each aspect is offered next.

Reliability is the issue of the level of consistency of the observed entities seen by researchers in similar cases, while **validity** is to what degree an explanation can symbolize an intervention (Hammersley (1992)). Reliability and validity are closely connected. In relation to findings, the focus is on lack of consistency measures and possible bias of the researcher. Therefore, we have endorsed several recommended techniques to overcome this, including seeking recursive impact from stakeholders to ensure consistent outcomes and reviewing the concluded findings with the research and development unit. These techniques correspond to the trustworthiness term suggested by Yin (2013), where he encourages prolonged involvement with data sources, persistent observation, and environmental understanding. In addition, the findings should not conflict with analytical statements of the literature. Finally, the outcomes must be presented comprehensively.

By what means should action research be evaluated? First, there is no approved group of rules and guidelines for the evaluation of this kind of study. It is largely acknowledged that following the methodology itself will eventually offer credible findings (Benbasat and Zmud (1999); Van Maanen et al. (1982); Yin (2013)). It is vital that the solution are based on grounds supported by the literature. Nevertheless, the aim of the research is to develop or as a minimum instigate developing hypotheses. Yin (2013) has noted that good hypotheses are cost conscious, assessable, and logically consistent. The preceding criteria appear to be the acknowledged criteria.

There are a number of questions to be asked to offer support for the hypotheses. Has the researcher followed a methodological practice? Do the findings support the hypotheses? Has the researcher excluded opposing descriptions? Has the researcher offered information on the settings of the case, data gathering/analysis methods, as in empirical studies? Has the researcher offered indications of alternative assessments? Although there are no quick

measures like correlation coefficients, methodical treatment of information can offer assurance that the findings and hypotheses are credible. Generally, a strong action research study has a strong, even if not inevitably faultless, coherence with information.

The progression of building hypotheses from an action case study is a noticeably **iterative** one. As a researcher might concentrate on a stage of the progression for a period, the progression itself entails continuous iteration in both directions between stages. For instance, a researcher might shift from feedback gathering, backward to redefinition of the problem, and forward to the point of final structuring of the hypotheses. In addition, the progression is active with opposition amid variant new ways of comprehending information and a unifying framework. An example of this would be in a procedure where there are several means of data gathering plus several cross-case observation techniques. Every observation technique entails examining practice from different viewpoints. Yet the procedure includes merging component definitions, assessments, and a framework for outcomes. In the end, the procedure is always united with empirical findings.

The outcomes from this action case study and our accessibility to a large empirical basis are vital to validating our approach and offering a convincing foundation for further development. Bear in mind that further case studies are required to examine additional aspects associated with our solution.

7.4 Strengths and Weaknesses of Action Research as Our Research Methodology

The following points offer an insight and discussion of the **strengths** of our research methodology:

The utilization of an action case study can profit from the projected benefit of **theory building**. As in [Eisenhardt and Graebner \(2007\)](#), action case studies are defined as explicit theoretical stimulants. Researchers can expect action case studies to act as plausibility probes involving initial efforts to resolve whether the original hypotheses are supposed to be declared sufficient to justify more thorough and broad examination.

The use of action case studies recognizes the significance of **deductive examination**

and process tracing as a central approach of development. [Bennett and Checkel \(2012\)](#) have mentioned this strength of offering such systemically rich examination. As followed in our research, encouragement is given to build explanatory hypotheses, and deductive assessment of the apparent consequences of causal methods to examine their explanatory potential ([Bennett and Elman \(2006\)](#)). Bennett and Elman have clarified that it includes offering a rational justification of the main chronological stages, as well as awareness of alternative justifications, with clear consideration of possible partiality in the presented evidence.

Another advantage of the use of an action case study is that it is **implicitly comparative**, as stated by [Bennett and Elman \(2006\)](#). The findings of such cases might not fit with the preceding theoretical outlook or broad empirical models. Nevertheless, the process of such cases would be able to develop transformed hypotheses designed to that particular case or probably generalize them, through the utilization of **inductive process tracing**. Action case studies are likely to offer a satisfactory justification if they are to have any future employment by any means.

The form of action case study will, through the employment of several qualitative/quantitative means, offer a **distinctive, empirically rich, comprehensive explanation of particular experience**. This is principally applicable within a scope such as EAM, where it is clearly less amenable to more external procedures and tests. A number of apparent gained advantages are named here: capability of capturing the extent of impact, availability of reliable information, suitability for practice and industry adaptations, appropriateness of potential large scale research, capability of inspiring change, and integration with potential problems.

The structure of the methodology, through the cyclic nature of development, enables the resulting contribution to benefit from two common advantages of the different nature of case studies. The first is the **prospective generalization** and the second is the **appropriateness of causal guidelines**. The simple strength of action case studies is the **existence of outcomes at a more practical rather than theoretical stage**. As Yin (2013) has stated the costly nature of action case study is overcome by outcomes that are more economical for organizations.

An obvious strength of employing an action case study methodology is the ability to analyse and **examine the proposed solution within the context of its use** ([Yin \(2013\)](#)), i.e. the examination contained by a state where the actual practice is conducted. This varies from an experiment, as it knowingly separates a case from its context, concentrating

on a restricted subset of variables ([Zainal \(2007\)](#)).

An additional strength of employing an action case study methodology is the **variations** as a consequence of fundamental, active, and cooperative approaches. Therefore, both quantitative and qualitative investigation of the case are enabled. Some research only depends on qualitative analyses from publications that offer expressive explanation of behaviour. Conversely, some research only depends on quantitative analyses from verification of numerical feedback of individual samples.

Another strength, besides its contribution to examining the proposed solution within the context of its use, is to **clarify the complexities of conditions in reality** that might not be captured in the course of experimental studies. For example, our case not only revealed the evolution among landscape representations in the matter of figures, but also revealed the reasons for change and triggers of the transformation. In addition, it gives indications as to how these triggers can be anticipated in comparison to other strategies.

A clear strength of action research is the thorough understanding obtained first hand. This is due to researcher participation in the implementation of the solution and at the same time assessing the outcomes of such intervention. Indeed, action research is conducted with the intent of progressing research whilst carrying out change, as the progression of change develops into the focus of investigation ([Zainal \(2007\)](#)). An example would be the unforeseen extensive analysis of EAM status. Our first goal is to make a start on solving a problem and to contribute a group of future progression concepts ([Sein et al. \(2011\)](#)). The latter is a significant contribution of our research.

A strength and a definition of action case study: There are three strengths of action case study research within the subject of information systems ([Benbasat and Zmud \(1999\)](#)). First, the case can be studied in its real settings, while the researcher can realize up-to-date practices and build theories from practice. Second, the environment and complications of the method can be observed. Third, the researcher can capture significant insights about original areas arising in the constantly changing subject.

The key strength of proposals constructed from action research is the capability of producing novel theory. Original observation is often the result of the combination of opposing or inconsistent evidence ([Bradbury and Reason \(2001\)](#)). Constructing proposals from action research focuses openly on this sort of combination. To be exact, we try to reunite evidence across information of different viewpoints, different accounts of cases, and different

researchers as well as alliance with the literature, which raises the probability of progressing original observation into a novel theory. While an illusion attached to action research claims that the methodology is restricted by researchers' preconceptions, actually the contrary is true. This continuous combination of opposing realities is likely to support novel thoughts, and consequently it offers the prospect of generating novel theory with minimal or no partiality, rather than theory generated from incremental research or axiomatic inference.

The resulting hypotheses are expected to be empirically valid. The probability of developing novel hypotheses is increased since the methodology has ensured its integration with evidence/empirical observation. Throughout the methodology, the researcher reflects on information from the starting point. This close interaction with empirical observation regularly generates hypotheses that directly reflect reality.

The following points offer an insight into and discussion of the **weaknesses** of our research methodology:

There is a recurring criticism of the utilization of action case studies in information systems; it relates to the **concern of methodological accuracy, researcher partiality, and independent validity**, as the findings can easily be affected by the researcher's personal partiality. Eisenhardt and Graebner (2007) and Fals Borda et al. (1991) have stated that researchers tend to ignore methodological considerations. Our plan to overcome this was to attempt to simplify and develop our methodological procedure and scientific foundation.

It should be considered that there are few arguments about the **actuality of generalization** from action case studies, i.e. how can a case consistently provide outcomes beyond the specifics of that case? The first argument is linked to the distinction between statistical and analytical generalization (Gerring (2004)). A case study is noticeably not very suitable for statistical generalization, yet can possibly maintain important value for analytical generalization. Gerring (2004) has stated that *theory confirmation or disconfirmation is not the case study's strong suit*. A familiar criticism would be the reliance on a single case investigation, which causes uncertainty over a generalizing deduction (Zainal (2007)). Therefore, it is encouraged to focus on parameter establishment and goals setting to support outcomes.

The second argument is linked to the **concern of case selection**. If it is done via a strategic approach, it will facilitate the potential generalization of the case, as affirmed by Seawright and Gerring (2008). The common selection of random or representative samples cannot guarantee the richest observation. Our selection process attempted to overcome

this by studying first the participative nature of various stakeholders and then selective representatives balanced across the various groups in the enterprise. After that, we employed the atypical selection for a minority of the samples. The latter is employed as it can reveal a richer insight, as claimed by [Flyvbjerg \(2006\)](#). However, it cannot be ignored that our selection process could be affected by availability and resources.

A clear weakness of employing an action case study methodology is the **high cost** because it been criticized as being hard to conduct, having numerous unforeseen tasks, and being considerably too long ([Yin \(2013\)](#)). The risk comes when the work is not maintained and structured methodically, as that might cause the waste of a great deal of time and resources. Even though the methodology was resource intensive, the majority of time was spent on observing and gathering feedback, while only a minor portion was spent on formal evaluation. Throughout the informal discussions and interviews, it is noticed that the assessment process had not annoyed participants excessively.

An apparent weakness of employing an action case study methodology is the inability to influence the context of the organization, i.e. its independent variables; this can put the outcomes in danger of inappropriate interpretation.

Another limitation is the **possible absence of objectivity** arising from the researcher's desire of reaching a successful result for the enterprise. Additionally, there is a potential weakness associated with future generalization endeavours when the researcher is not part of them, where the proposed solution is employed by less well-informed individuals. Examples of action research in different frameworks can be viewed in [Benbasat and Zmud \(1999\)](#).

There are a number of concerns related to the use of such methodology and time. The time-consuming nature of data analysis is a concern for researchers. In addition, data gathering in qualitative research is more time-consuming, especially when it is compared with quantitative studies.

An important task preceding the conduct of action research is **site selection**. Site selection refers to the organization where the action case study takes place. It is advised that it should be chosen methodically rather than opportunistically. It should be mentioned here that our selection was partially opportunistic. There are a number of recommendations when it comes to site selection, including considering the nature of the subject and declaring characteristics of the desired organization (industry, organization size, structure, geographic exposure, profit/non-profit, public/private, and utilized technologies/methodologies).

Few qualities of action research generate strengths but also generate weaknesses, such as the concentrated exploitation of empirical evidence which can discard theory due to the complicated nature of the theory. To be exact, rather than offering concrete short hypotheses as advised, one could tend to offer hypotheses that attempt to capture everything, which is motivated by the volume of information. The outcome can be very rich comprehensively, but lack the required simplicity. Therefore, we attempted in this study to gather a high volume of data and yet only exploit the minimum for the scope of this research. A high proportion of action studies do not have quantitative measures like regression effects or remarks from several studies. This may result in inability to determine the key issues/associations rather than issues specific to one case/site. Therefore, we have started to gather information across different enterprises. The data to be collected will be presented in future work, as it is not part of the scope of this research.

Summary of the Evaluation Chapter

Section (7.1) presented the evaluation of our solution by analysing the satisfaction of participating stakeholders in relation to the requirements of business behaviour management, maintenance of EA models, and shared stakeholders' understanding. In addition, we evaluated the impact of employing our solution on the EAM practices within Al-Elm.

Afterwards, we offered a critical reflection on our action research involving limitations (7.2), discussion points (7.3), and analysis associated with the use of action research as our research methodology (7.4).

Chapter 8

Conclusions

In this chapter, we first offer a critical reflection on lessons learned during our action research (8.1). Second, we present an outlook on future improvements and research points, see Section (8.2). Finally, we outline the achievement of our research questions an addition to our main contribution, see Section (8.3).

8.1 Learned Lessons

There are a number of lessons learned throughout different stages of the development:

The four key principles we learned to incorporate to drive our research methodology are named here. First, feedback cycles were integrated during the implementation to ensure that the stakeholders were fully engaged and that their final remarks are credible. Second, it is important to keep a balance and separation between our three roles as a designer of the solution, as a participant in the employment, and as an evaluator. Third, it was key for stakeholders to be involved in the ongoing decisions on the enhancements of the solution in order to ensure their commitment and enthusiasm. Fourth, a sequential assessment process needs to be incorporated to overcome any conflicting input by collecting information.

This research shows the viability of a qualitative methodology to realize reliable collective results by means of a composite and non-standardized evaluation mechanism. This depends on an inclusive and comprehensive practised evaluation via the feedback of the action case study. We integrated a number of principles into the evaluation practice to reach utmost credibility of the outcomes, as identified in the previous paragraph.

During the course of qualitative research, the researcher is principally responsive to changes that happen throughout the action case. This has an unforeseen consequence, which is the potential change of focus of the research, including even the challenges and solution. This is an important learned lesson obtained from the participation in the study.

During the course of the action case study, the first intention was to employ a solution to a problem identified in the literature. Subsequently, a researcher will find that they will be instead sunk into investigating how and why phenomena occur. For example, in our case, this led to changes in the identified challenges and the proposed techniques to achieve a solution.

Throughout the action case study, a researcher can understand and verify how stakeholders use and interpret elements of a system. For example, we were never able to realize the actuality of framework utilization; we started the work following the open group architecture framework (TOGAF) ([The Open Group \(2009b\)](#)) structure, and subsequently realized the actual customization of elements of the framework.

Thus, data would be gathered in its naturalistic settings. In addition, environmental settings have an impact on the findings; at the same time this is considered an advantage, as they are responsive and provide an insight into local circumstances, conditions, and stakeholders' needs. So, an account of the case must describe in detail the case as it is placed and embedded in constrained contexts. The research is thus situated in a specific context and setting.

The scope of identified research might have to be adapted during the course of the action research. For instance, we approached the foundation of enterprise architecture management (EAM) framework and standard 'enterprise architecture management language (EAML)' as opposed to one framework due to the nature of usually customized EAM frameworks in enterprises and our own action case study.

An important lesson indicates that what seems to be useful and effective in the literature may not always be considered and approved in practice.

We outlined detailed discussion points offering a critical reflection on our action research and proposed methodology, see Section (7.3) in Chapter (7).

8.2 Future Research Points

A number of the issues extracted from and motivated by this action research require further work and examination, in addition to issues that are beyond the scope of this research. These issues and how they will construct **future research points are described in this section:**

A number of the identified requirements were partially or not fulfilled by our solution, as discussed in Chapter (7). Future work is needed to fulfil them. The following names these requirements: The simplicity of assignments of responsibilities to stakeholders have not improved. The visibility of initiatives' goals seems to be a missing aspect of our solution. Our solution has showed no improvement in regard to distinctive views of multiple concerns of the same stakeholders. However, this confirms previous remarks stating the need for better visualization capacity in the form of viewpoint models rather than just the information models offered in our solution. In comparison with current approaches, we also lacked the modelling capability to project views for every identified concern. Additional requirements are provided in the next paragraph.

As our solution did not address the challenge of a visual roadmap, it is indicated that our extended meta-model might affect this issue negatively. In relation to the projection of drafts of future landscapes, we need to offer a comprehensive explanation of future application landscape from a logical perspective, i.e. architecture blueprint. Our solution lacked the ability to link components of business mental models to components of technology. A particular technique is needed to improve business stakeholders adaptability to future states. Additional meta-information was suggested for future improvements, such as involving new predefined attribute types. Future work has to be conducted to find a way to ensure complete identification of expired and eliminated constituents, as our work could not fulfil this challenge. we were not able to optimize the transformation conducted with the aim of integrating new data coming from external information systems as manual activities were still needed.

A potential future point is the introduction of prototypical tool execution and guidance to supposed employment in reality. We would advise it to be complemented by theoretically describing tool support by evaluating the proposed approach against the previously identified challenges from practice and literature.

We have identified possible participants' partiality as a limitation of our solution. Therefore, additional analysis on the impact of participants' partiality on our proposed methodology needs to be undertaken to prove it to be true or not.

. Future research should study and identify any resemblances to different existing enterprises' functions. All new developments of EAM frameworks need to be examined in order to illustrate resemblances to different enterprises' functions in which association to high-level goals can come into view.

Exploring methods for new practices is required to lower enterprises' reliance on manual EAM efforts. We plan for further research to principally explore methods for team cooperation and new practices to improve EAM ability to standardize these practices in order to be a practical step towards automation.

Extending the solution design to parallel enterprise architecture (EA) functions is an additional recommendation for future work. This can be achieved by defining, reshaping, and combining patterns and extension blocks in order to offer model practices to enterprises.

Progression levels of automation attempts within enterprises is a significant future area of development. However, it requires very high resources and access to practical contexts. Our action case study and questionnaires acknowledged that a proportion of enterprises already employ automated EAM patterns to deal with some dynamic aspects. It is up to additional studies to identify the progression levels of these attempts.

Future development should accomplish all tasks empowering the solution on the way to its adaptation by a major EAM framework. This will eventually lead to the inclusion of additional measures to overcome recurring development of EAM frameworks.

We plan for further research to deal with organizational and technological difficulties in order to offer and maintain automation mechanisms. In line with [Buschle et al. \(2012\)](#), [Holm et al. \(2014\)](#), and [Hauder et al. \(2012\)](#), we outline the need for advanced research that can also evaluate existing data sources of functioning technological procedures for automated EAM practices.

The planned research can benefit from techniques and tools offered in different perspective subjects, where diverse high levels across EAM can profit from these tools, and not just the technological layers. By means of this utilization, particular tool support may well develop automated data gathering and accordingly ease EAM extraction and documentation

approaches.

Integration with additional building blocks is an interesting prospective. In light of the outcomes, we intend further research to combine our approach with planned method building blocks that we aim to develop to address the previously mentioned future points of developments and eventually apply it to forthcoming EAM procedures.

Our continuing objective is to develop a library that enables the integration of best practice extension blocks that optimize diverse practices across the organizational environment. The targeted aspects need to be first approved and reviewed by the industry; this would be considered as one of the first steps in future development of this research output.

Additional application scenarios should be offered and tested to improve the applicability of the solution. Our conducted action case study, interviews, and questionnaires have already presented important proposals as an initial indication for additional application scenarios of our proposed approach. The future research will offer clear identification of these scenarios supported by sufficient guidelines.

Consideration of obtained feedback exceeding the scope of our research would address the relevant insights discussed in Chapter (7). All stakeholders' reactions and remarks have to be incorporated, especially the feedback primarily associated with developments of further involvement when it comes to grasping high-level goals. This should be done with the inclusion of additional information sources.

We should maintain and update the techniques and guidelines to be in harmony with any new solutions in the field. The guidelines, generalization, and remarks offered with our solution should be extended and reviewed to cover any limitation within this research. This has to be done in accordance with practice and in alliance with current EAM frameworks.

Another point of continued study is the usability of the solution; in order to examine if it is more practical to expand this solution to work with every framework or to limit its usability within TOGAF.

Bearing in mind individual experience influence on a particular stakeholder, the sketch of potential employment of a single initiative's need has to be designed in advance, including all involved mechanisms. For clarification, in our case the design of the solution needs to be built and adapted by respective architects.

A strongly suggested feature is to offer additional visualization capacity, especially when it comes to evaluating the progress of an initiative. This will enable relative stakeholders to view EAM function evolution. As our proposed meta-model enables the representation of such progress, this is suggested in the manner of a viewpoint model.

Apart from the previous point, the implementation of our solution shows that it is compliant with the TOGAF nature of processes, and this could be different when it comes to other frameworks. Further investigation is required to validate this claim of compatibility.

Further research can benefit from our solution's incorporation of informal guidelines and know-how documented in enterprises, by offering enhancements as potentially new patterns of standard solutions for new problems. These would involve patterns integrating contextual business behaviour.

The enterprises' ability to address dynamism would offer support for further EAM processes. A few stakeholders have offered important remarks. They have questioned the manner in which the support should be offered for further EAM processes. The question would be how new solutions should be offered, whether as a standalone mechanism or as part of EAM frameworks' tool support.

Extensive textual descriptions of our EAM solution is being developed in collaboration with Al-Elm, the participating stakeholders were the motive behind this step. The participating stakeholders have provided more than one basis for the benefits that would be attainable from a suitable support for the solution such as in textual description. One of their remarks suggests that the support will only be helpful if it has suitable tool support. A number of the highly experienced participants have encouraged the standardization of the solution with the condition of offering guidelines for enterprises employing the solution.

A desirable future research point is to challenge the findings by peers with the purpose of producing more solid refined evidence. In addition, it might be beneficial to offer a more detailed account of the case and to offer another source of evidence. Another way to challenge the findings is to undertake cross-case comparisons and analysis. This research point is in relation to the abundant discussion of the reliability and validity that constitutes a part of the credibility of the findings.

One consultant has suggested the adaptation of a pattern structure to be offered for clarity and help for stakeholders. The solution's ability to additionally distinguish between methodology, viewpoint, and information model aspects was considered to be beneficial.

Clarity is important because more frequent changes in initiatives are anticipated rather than in the actual process.

8.3 Conclusion

This section signifies the achievement of our research questions, which were identified in the introduction Chapter in Section (1.3). The research questions have guided the development of our solution, as explained in Chapter (6). We outline the efforts for achieving them.

1. By what means can we ideally support the constant stakeholders' need for information that is governed by the particular business behaviour/context of their enterprise?
 - We propose a number of techniques to compliment the 'architectural development method (ADM)' of TOGAF, see Section (6.5) in Chapter (6). These techniques facilitate structured data maintenance of EA in order to minimize manual practices preliminary to modelling and to enable the generation of change at timely events in order to enhance the actuality of EA landscape.
 - The evaluation of our solution in relation to this question has indicated satisfactory fulfilment as discussed in Section (7.1.1) in Chapter (7). We analysed the satisfaction of corresponding stakeholders with consideration to the requirements and existing approaches identified in Chapter (5).
2. By what means can we ideally enable building EAM models reflecting constant change in business behaviour and goals, and consequently improving the planning of target EA states?
 - We propose our extended meta-model that enables the representation of our proposed techniques in order to facilitate further capacity in line with constant changes in business behaviour, see Section (6.3) in Chapter (6).
 - The evaluation of our solution in relation to this question has indicated satisfactory fulfilment as discussed in Section (7.1.2) in Chapter (7). We analysed the satisfaction of corresponding stakeholders with consideration to the requirements and existing approaches identified in Chapter (5).
3. By what means can we ideally produce an EA landscape reflecting the different mental models of stakeholders?

- We highlight the significance of a joint understanding of business behaviour among diverse stakeholders. In addition, we elicit and propose a number of driving guidelines for an improved modelling design of EA by communicating and accepting a shared business behaviour between involved stakeholders, see Section (6.4) in Chapter (6).
 - The evaluation of our solution in relation to this question has indicated satisfactory fulfilment as discussed in Section (7.1.3) in Chapter (7). We analysed the satisfaction of corresponding stakeholders with consideration to the requirements and existing approaches identified in Chapter (5).
- Research Question: Can an adapted or extended EAM framework be developed to deal with the dynamic business behaviour of an enterprise?

We achieve this driving research question by offering the contribution of our action research as a whole. Our contribution is the proposed **methodology** for managing changing business behaviour, which adapts a number of techniques enabling enterprises to pick what matches their contextual needs. This methodology relies on the capacity offered by our extended meta-model. The evaluation of the impact of employing our solution on the EAM practices is discussed in Section (7.1.4) in Chapter (7).

All in all, we relied upon action research to explore a new approach to enable the representation of adaptive practices needed to support and customize standard frameworks. These practices deal with the constantly changing business behaviour. The ability to represent such additional practices as part of the structured EAM frameworks is of high practical significance. We identified the requirements enabling such incorporation, and offered simple and practical means to achieve this change. Our proposed methodology reflects adaptive business practices, ie, the ways in which businesses adapt standard frameworks, in order to achieve comprehensive enterprise architecture modelling, and we offered an extended capacity to represent knowledge held by individuals. We evaluated our methodology by the use of an action case study. This practical employment offered valuable insights into the applicability and usability of our methodology in practice. The outcomes from the action case study indicated the limitations, degree of fulfilment, and needed improvements.

Appendices

Appendix A

Questionnaire

The questions were transmitted via the internal electronic network of Al-Elm. In regard to the survey sent to participants in external enterprises, they were supported with a link included in the emails sent to them. The link connected them to a secured page comprising the survey. Some of the remaining questions can be found in Figures (7.8, 7.9, 7.10, 7.11) which were part of the questionnaire-based interviews to evaluate our solution.

Questionnaire Part (A)

Answer the following questions to form our empirical examination of EAM practices in Saudi Arabia regarding the following areas of concern:

A.1: Numbers of years working with EAM frameworks

1 to 3 years ☐ 4 to 6 years ☐ more than 6 years ☐ none ☐

A.2: Number of Enterprises where you have experienced working with EAM frameworks

1 enterprise ☐ 2 enterprises ☐ 3 enterprises ☐ none ☐

A.3: Nature of interaction with EA

EA Architect ☐ Business stakeholder ☐ Finance stakeholder ☐
 Technical personal ☐ other ☐

A.4: Familiarity with which EAM framework

TOGAF ☐ EAMPC ☐ Zachman ☐
 Customized ☐ other ☐

A.5: Is there any own solution built within the organization

Yes ☐ No ☐

A.6: Modelled state of the EAM function in organizations

Total ☐ Finance ☐ Government ☐
 IT, Technology (Current/ Planned/ Long-term target) ☐ other ☐

Questionnaire Part (A)

Answer the following questions to form our empirical examination of EAM practices in Saudi Arabia regarding the following areas of concern:

A.7: Key Challenges in Enterprise Architecture Management Team Organization

- Insufficient tool support ☐ No management support ☐
- Low return on investment ☐ Huge effort of data ☐
- Bad quality of EA model data (actuality, consistency, completeness, etc. ☐
- Other ☐ ----- No specific challenge ☐

A.8: How are the teams for the EA data collection organized

- Collected by central EA team ☐ Both, collected by centralized and federated teams ☐
- Collected by stakeholders in other organizational units (federated EAM) ☐
- I don't know ☐

A.9: How is the manual EA data collection organized? Type of Collection (Multiple choices were possible)

- Manually from applications ☐ Databases ☐ Manually via interviews ☐
- Manually modelled in workshops ☐ Manually via questionnaires ☐
- Partially collected automatically ☐

A.10: Does your organization have a dedicated and specified process description for the data collection? Process Available

- No ☐ Yes ☐ I dont know ☐

A.11: Has your organization implemented some form of automated update mechanism for your EA tool? (Automation)

- No ☐ Yes ☐ I dont know ☐ No EA tool in use ☐

Questionnaire Part (A)

Answer the following questions to form our empirical examination of EAM practices in Saudi Arabia regarding the following areas of concern:

A.12: What are the triggering events for updating contents of your EA model? (Multiple choices are possible.) (Triggering events)

- Periodic checks by enterprise architects with data providing stakeholders ☐
- Acquisition of new products (applications, hardware, etc.) ☐
- Trigger model updates by enterprise architects ☐
- New application releases trigger model updates by enterprise architects ☐
- Project completion ☐ Inception triggers EA update process ☐
- Introduction of new business processes trigger model updates by enterprise Architects ☐
- Data providers contact the enterprise architects on changes in the real world Enterprise Architecture ☐
- Mergers & Acquisitions trigger model updates by enterprise architects ☐
- A ticketing/task list (application) is used to manage EA change requests by different stakeholders ☐
- Change in external tool automatically triggers manual update task e.g. project completion in project management tool ☐
- other ☐

A.13: What are the key EA documentation challenges in your organization?

- It is very time consuming to collect the data ☐
- Information is difficult to acquire ☐
- Sufficient EA model actuality is not achieved ☐
- Information is not available ☐
- It is difficult to get hold of the right stakeholders as data providers ☐
- The information is too fine grained ☐
- Real world EA changes too quickly to synchronize EA model ☐
- It creates inconsistencies in the model ☐
- Other ☐ No specific problems ☐

Questionnaire Part (A)

Answer the following questions to form our empirical examination of EAM practices in Saudi Arabia regarding the following areas of concern:

A.14: How automation is technically implemented in your organization?
(Multiple choices are possible) (Implementation)

Excel Import ☐ Relational Database Import ☐ CSV Import ☐
XML Import ☐ SOAP Web Service Interface ☐
REST Web Service Interface ☐ I dont know ☐

A.15: Do you consider the need for further assessment for requirements analysis functionality a necessity for improved EAM functionality?

No ☐ Yes ☐ I dont know ☐

A.16: Have the tool selection process and analysis activities of the EA required IT involvement?

No ☐ Yes ☐ I dont know ☐

A.17: Would you advise your organization to develop its own customized software solution to deal with Data Maintenance challenges?

No ☐ Yes ☐ I dont know ☐

A.18: Which one of the following you would consider the best option to handle current limitation with EAM framework?

Integration with other EAM framework ☐ Customized software solution ☐
Acquisition with general purpose software tool ☐ other ☐ _____

A.19: Which one of the following you would consider pivotal to the business requirements analysis part of EAM? (multiple solutions)

Appropriate choice EAM framework ☐ Experienced Personal ☐
The proper technology must have the capability to comprehensively express the current EA of the organization ☐
Sufficient time to identify prcis future business requirements ☐ other ☐ _____

Questionnaire Part (A)

Answer the following questions to form our empirical examination of EAM practices in Saudi Arabia regarding the following areas of concern:

A.20: What would be considered the key to future success of upcoming solutions? (Multiple solutions are possible)

- Documentation of current practises ☐ Consultation ☐
- Development of a dedicated approach to solve the problem ☐
- Refinement of current capabilities in EAM frameworks/ Using familiar solutions ☐
- other ☐ -----

A.21: What are the current practises used for documentation in organizations applying EAM?

- Data warehouse facility ☐ Textual description ☐
- Utilization of offered Information models in EAM frameworks ☐ other ☐ -----

A.22: During the implementation of new initiatives, was there any missing data associated with the new initiative requirements?

- No ☐ Yes ☐ I dont know ☐

A.23: What are the effects of implementing multiple solutions that treat same sub-requirements?

- High lost effort in relation to implementation ☐
- Extra cost in relation to data validation ☐ other ☐ -----

A.24: In your organization, who is in charge of making decisions regarding new solutions?

- Business stakeholders ☐ IT stakeholders ☐

A.25: What are the main needs you believe will help achieving high level goals?

- Suggested Improvement 1:-----
- Suggested Improvement 2:-----
- Suggested Improvement 3:-----

Questionnaire Part (B)

Scale your satisfaction of the solutions' employment to the degree of your participation as a stakeholder in the enterprise in relation the following points of concern:

B.1: Clear and managed responsibilities

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

B.2: Developing initiatives and templates

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

B.3: Flexibility throughout execution

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

B.4: Visibility of initiative progression

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

B.5: Observable development of initiative

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

Questionnaire Part (B)

Scale your satisfaction of the solutions' employment to the degree of your participation as a stakeholder in the enterprise in relation the following points of concern:

B.6: Transparency and visibility of initiative goals

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

B.7: Hierarchical structure of activities

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

B.8: Clear and simple assignment of responsibilities and roles

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

B.9: Integration of attributes to the initiative

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

B.10: Identification of rational dependencies across activities

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

Questionnaire Part (B)

Scale your satisfaction of the solutions' employment to the degree of your participation as a stakeholder in the enterprise in relation the following points of concern:

B.11: Comprehensible and flexible for business stakeholders

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

B.12: Flexibility of enabling new roles and stakeholder at run-time

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

B.13: Identification of temporary and pre conditions

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

B.14: Availability of guidelines

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

B.15: Business stakeholders' adaptation at run-time

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

Questionnaire Part (B)

Scale your satisfaction of the solutions' employment to the degree of your participation as a stakeholder in the enterprise in relation the following points of concern:

B.16: Projection of drafts of future Landscapes

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

B.17: Multiple states identification

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

B.18: Business stakeholders' adaptability to future states

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

B.19: Visibility of Application Landscape Roadmap

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

B.20: Visible views for different stakeholders concerns

Lowest					Highest
☐	☐	☐	☐	☐	
Suggested Improvement:.....					
.....					

Questionnaire Part (B)

Scale your satisfaction of the solutions' employment to the degree of your participation as a stakeholder in the enterprise in relation the following points of concern:

B.21: Trilogy of associations

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

B.22: Visualisation of business support providers

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

B.23: Inference of target landscapes

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

B.24: Landscape variation

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

B.25: Traceability of stakeholders' decisions

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

Questionnaire Part (B)

Scale your satisfaction of the solutions' employment to the degree of your participation as a stakeholder in the enterprise in relation the following points of concern:

B.26: Classifying Divergent & Convergent Initiation Phase

Lowest					Highest	
☐	☐	☐	☐	☐	☐	
Suggested Improvement:.....						
.....						

B.27: Collecting participation from diverse stakeholders

Lowest					Highest	
☐	☐	☐	☐	☐	☐	
Suggested Improvement:.....						
.....						

B.28: Meta-modelling for the intention of generalisation & learning

Lowest					Highest	
☐	☐	☐	☐	☐	☐	
Suggested Improvement:.....						
.....						

B.29: Maintaining simplicity & transparency

Lowest					Highest	
☐	☐	☐	☐	☐	☐	
Suggested Improvement:.....						
.....						

B.30: Validating with Data

Lowest					Highest	
☐	☐	☐	☐	☐	☐	
Suggested Improvement:.....						
.....						

Questionnaire Part (B)

Scale your satisfaction of the solutions' employment to the degree of your participation as a stakeholder in the enterprise in relation the following points of concern:

B.31: Implications on productivities

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

B.32: Landscape Maintenance

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

B.33: Progression of EAM function

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

B.34: Minimising expenses of the enterprise

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

B.35: Preserving activities within the boundaries of model's objective

Lowest					Highest
☐	☐	☐	☐	☐	☐
Suggested Improvement:.....					
.....					

Appendix B

Author's Current Publications of Research

TABLE B.1: Author's current papers

Calendar year of publication	Title of paper	Where article published
(1) 2012	Requirements Analysis: Evaluating KAOS Models.	Journal of Software Engineering and Applications, Volume 3, JSEA 3(9): 869-874 (2012)
(2) 2012	The Design of a new EAM Framework in opposition to improving some existing features.	RESG Workshop/British Computer Society/University College London.
(3) 2012	A framework to drive novel research in the area of EAM	- Imperial College Computing Student Workshop/Imperial College London
(4) 2013	Proposed Research Method For Enterprises Employing Enterprises Architecture Management	- KACSTIT 2nd Saudi International Conference on Information Technology, Published in the proceedings of the conference
(5) 2014	An Analysis of Enterprise Architecture Frameworks	MDBPE 2012/published as part of a Book: Model-driven Business Process Engineering, Bentham Science

Appendix C

Acronyms

ADM Architecture Development Method
AutoGA Automated Gathering with Assessment
BDM Business Dynamics modelling
CG Change Generator
DSL Domain Specific Language
EA Enterprise Architecture
EAM Enterprise Architecture Management
EAML Enterprise Architecture Modelling Language
EAMPC Enterprise Architecture Management Pattern Catalog
E2A Extended Enterprise Architecture
E2AF Extended Enterprise Architecture Framework
FEAF Federal Enterprise Architecture Framework (US)
IEEE Institute of Electrical and Electronics Engineers
independentCG Independent Change Generator
innerCG Inner Change Generator
IS Information Systems
ISO International Organization for Standardization
IT Information Technology
MOF Meta Object Facility
OMG Object Management Group
RDU Research and Development Unit
TAR Technical Action Research
TimelyIT Timely Indicator of Tasks
TOGAF The Open Group Architecture Framework
UML Unified Modelling Language

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