Corvinus University of Budapest

On Exposing Strategic and Structural Mismatches Between Business and Information Systems:

Misalignment Symptom Detection Based on Enterprise Architecture Model Analysis

Ph.D. Dissertation

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Dóra Őri

Budapest

2017

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ABSTRACT

One of the most important issues on information systems (IS) research is the need to align business with information systems and information technology (IT). Since information systems facilitate the success of business strategies, the importance of business-IT (or strategic) alignment is unquestionable. While organisations address alignment achievement, they are continually suffering from misalignments. These difficulties (the misalignments) encumber the achievement of alignment and lead us to the phenomenon of misalignment. This Ph.D. dissertation deals with the concept of misalignment, with special attention on enterprise architecture (EA)-based analytical potential. In the following study, the problem of business-IT alignment will be translated into the aspects and concepts of enterprise architecture. The main purpose of the proposed research is to analyse strategic misalignment between the business dimension and the information systems dimension. In this Ph.D. dissertation, an analytical solution will be built to approach the topic of strategic alignment from an EA-based perspective. The study aims to accomplish an EA-based, systematic analysis of mismatches between business and information systems. The operation, the correctness, as well as the relevance of the framework will be validated via a case study. The contribution of the proposed study lies in connecting typical misalignment symptoms to relevant EA analysis types along traditional alignment perspectives. The significance of the proposed research is the clear and accurate compound of research methods and implementation instruments to approach EA-based misalignment symptom detection. The results of the proposed research will contribute to alignment assessment by expanding the ways of addressing alignment problems. The proposed research framework has the potential to extend our understanding on assessing the state of misalignment in a complex EA model structure.

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1 INTRODUCTION

The concept of IT strategy and management has been circulating around my research interest since I was introduced to the field of Business Information Technology. During my education, I immersed myself in Strategic Alignment studies. I have started my Ph.D. studies in order to gain insight into the theoretical background as well as the practical application of IT strategy planning, especially alignment assessment. My commitment to the concept of Strategic Alignment was finally sealed when I became acquainted with the concept of misalignment, i.e. approaches to examine strategic alignment from its shortages and deficiencies. In search of a relevant and appropriate research tool for misalignment assessment, I was introduced to the concept of Enterprise Architecture Management which proved to be a proper approach for assessing the state of misalignment in an organisational context. The idea to connect strategic alignment with well-known enterprise architecture methods and tools seemed to be a good method for identifying misalignments by using already existing architecture models. In addition, using misalignment symptoms as a pivot to go from strategic alignment perspectives to enterprise architecture assessment methods indicated a possible contribution to narrowing the research gap around the possible methods of alignment assessment. The research framework introduced in the Ph.D. dissertation contributes to the support of business-IT alignment. The proposed Ph.D. dissertation contains my devoted progression in this highly respected mixture of research topics.

The aim of the introduction is to provide background for all the research details that are to follow in the subsequent parts of the study. This section sets the context of the proposed research. The introduction is considered as a focused overview with the main goal of stating the importance of the research problem. In addition, this section aims to establish a general research model in order to clear up the constituent parts as well as the inherent linkages of the proposed research.

1.1 Motivation

One of the most important issues on information systems (IS) research is the need to align business with information systems and information technology (IT). Since information systems facilitate the success of business strategies, the importance of business-IT (or strategic) alignment is unquestionable. This connection indicates the importance of alignment between business and information systems. The need for aligning business and IT consists of several reasons, e.g. using IT effectively to achieve business goals, capturing the ability of IT to create business value, bridging the gap between business and IT or integrating IT to business strategy, mission, and goals (Chan and Reich, 2007).

While organisations address alignment achievement, they are continually suffering from misalignments. These difficulties (the misalignments) encumber the achievement of alignment and lead us to the phenomenon of misalignment, which is referred to as the inverse state of strategic alignment. In this undesired state, organisations fail to achieve or sustain alignment, i.e. information systems and information technology are not used consistently with the business strategy. In addition, strategies, structures, processes, and technology considerations are not perfectly harmonised between business and IT domains in an organisation.

Misalignment analysis (detecting, correcting and preventing misalignment) is an important step in achieving alignment since it helps to understand the nature and the barriers of alignment. In addition, it supports organisations in proposing certain steps to (re)achieve alignment.

Understanding the underlying cause of misalignments, as well as trying to correct the existing misalignments are one of the possible ways to achieve alignment (Carvalho and Sousa, 2008). Misalignment is, therefore, a key issue in alignment achievement. If an organisation can catch the evidence of misalignment, it is on the way to being able to correct them. If misalignment evidence are corrected, the state of alignment can be achieved (Carvalho and Sousa, 2008).

Most traditional alignment studies deal with achieving alignment. On the contrary, misalignment issues (detecting, analysing and correcting misalignment) are considerably underemphasised in literature. The little attention to misalignment is inadmissible since organisations are in the state of misalignment as long as they achieve the state of alignment. This fact indicates that more attention ought to be paid to the phenomenon of misalignment, as well as to its symptoms and effects. There are several questions among the concept of misalignment. Answering these questions contributes to alignment achievement. The most important issues of misalignment are the following:

1) How to detect misalignment symptoms?
2) How to alleviate identified symptoms?
3) How to reveal the underlying causes of misalignment?
4) How to address these underlying causes?

The state of (mis)alignment can be examined with several methods. Most of the methodologies approach (mis)alignment from management, organisational culture, and communication perspectives. In contrast to popular approaches, one of the main research methods for (mis)alignment evaluation is enterprise architecture-based assessment. Enterprise architecture management (EAM) is becoming increasingly popular nowadays. Also, it helps to reveal the state of alignment. A possible improvement of enterprise architecture based alignment assessment is to conduct the evaluation from the opposite perspective: assessing misalignment through enterprise architecture models. In this case, the purpose of analysing enterprise architecture models is to assess the state of misalignment and to reveal its emerging symptoms.

In order to assess the presence of misalignment in an organisation, several approaches can be used (such as the approaches of Carvalho and Sousa (2008) and Strong and Volkoff (2010)). However, the innate ability of the enterprise architecture (EA) concept to support the detection of misalignment signs is scantily addressed in literature (for exceptions see e.g. Castellanos and Correal (2012), Pereira and Sousa (2005) and Sousa et al. (2005)). At the same time, well-established alignment methods are rarely incorporated into misalignment assessment methods. Equal importance should be given to the existing and the innovative ways of approaching misalignment since traditional alignment methods have been proven to be feasible. This Ph.D. dissertation deals with the phenomenon of misalignment, with special attention on enterprise architecture-based misalignment analysis.

1.2 Problem Statement

The proposed research relates to the concept of strategic alignment. The assessment of organisational alignment can be approached from several views. This research aims to approach strategic alignment from the perspective of misalignment, i.e. from the opposite state. In this research, the problem of detecting the typical symptoms of misalignment will be addressed in order to assess the state of alignment in an organisation. The research aims to provide suitable tools and instruments to detect the symptoms of misalignment. Misalignment assessment will be based on the analysis of the underlying enterprise architecture models.

For general context setting, the proposed research works with the concepts of strategic alignment, misalignment and enterprise architecture. From the alignment perspective, the research is built on the traditional Strategic Alignment Model (SAM) by Henderson and Venkatraman (1993). Misalignment assessment relies on the symptom detection approach. EA-based analysis uses the TOGAF enterprise architecture framework (TOG, 2015), and is based on rule generation and testing. The problem addressed in the Ph.D. dissertation is the identification of suitable ways to approach EA-based misalignment assessment. Alignment assessment will be performed from the perspective of misalignment. The state of misalignment will be revealed by its symptoms. Symptom detection will be performed via an EA-based approach, i.e. the underlying EA models will be analysed in order to reveal the symptoms. To achieve EA-based misalignment symptom detection, EA model matching techniques will be used. Based on the constituent parts, the research aims to build a framework for EA-based misalignment symptom detection.

1.3 Purpose of the Study

The study discusses strategic misalignment between the business dimension and the information systems dimension. The aim of the study is to contribute to the above-mentioned concerns and gaps by introducing a framework that addresses these issues. The study conducts misalignment analysis by proposing an enterprise architecture-based framework to detect the typical signs of misalignment in an organisation. The proposed framework performs misalignment analysis by taking a symptom-based approach. It aims to accomplish an EA-based, systematic analysis of mismatches between business and information systems.

The framework builds on the traditional SAM model, in particular on the concept of alignment perspectives (Henderson and Venkatraman, 1993). Misalignment symptoms are connected to the four traditional alignment perspectives (Strategy Execution, Technology Transformation, Competitive Potential and Service Level). The framework identifies typical misalignment symptoms within the traditional alignment perspectives. Relevant EA artefacts and EA analysis types are recommended to every detected symptom along the perspectives. The justification of recommended artefacts and EA analysis types lies in the following: EA artefacts may contain the misalignment symptom in question, while EA analysis types are – by functionality – able to detect the symptom in the artefacts. Both the arguments for the chosen misalignment symptoms and the arguments for the selected EA analysis types will be presented in detail. The specific contribution of the study lies in connecting typical misalignment symptoms to relevant EA analysis types along traditional alignment perspectives.

This Ph.D. dissertation first establishes the theoretical background of architecture-based misalignment symptom analysis by the introduction of building blocks and related work. Based on the theoretical foundation, the study aims to connect these building blocks to each other in order to create an architecture-alignment perspective. After setting theoretical context, a research model is given which connects enterprise architecture and misalignment assessment by analysing misalignment symptoms in different architecture domain matches. The operation of the proposed framework is introduced in detail by presenting a case study.

The research contributes to theory and practice as well: its innovative approach is conducive to academic business-IT alignment results. Additionally, its practical application helps organisations to detect and correct misalignment in order to achieve the state of alignment. The proposed research extends the existing body of knowledge in the field of enterprise architecture and strategic alignment. It exploits and utilizes the innate connection between the concepts of strategic (mis)alignment and enterprise architecture. By proposing a formal approach to analyse the state of misalignment, it provides new conceptual insights into the research field of alignment assessment and EA analysis.

The significance of the proposed research lies in the clear and accurate compound of research methods and implementation instruments to approach EA-based misalignment symptom detection. The results of the proposed research will contribute to alignment assessment by expanding the ways of addressing alignment problems. By approaching alignment from the perspective of misalignment, a fresh direction will be strengthened in the field of alignment assessment. Additionally, by using underlying EA models for misalignment assessment, the implicit connection between the concepts of (mis)alignment and enterprise architecture will be further cultivated. Finally, the use of formal analysis techniques will form the basis for precise EA analysis methods. From a methodological perspective, the significance of the research lies in the combination of Design Science and Case Study research methodologies. In addition, methodologically significant contribution lies in supporting the Design Science Research method with additional EA-based research methodologies.

Expected outcomes from the proposed research include:

EO1:	CLASSIFICATION OF DIFFERENT MISALIGNMENT SYMPTOMS: EA INDICATORS ON MISALIGNMENT, EA DETECTION TECHNIQUES
EO2:	A FRAMEWORK WHICH CAN SUPPORT EA-BASED (MIS)ALIGNMENT ASSESSMENT
EO3:	CASE STUDIES ON THE OPERATION, CORRECTNESS, RELEVANCE, ACCURACY AND RESULTS OF THE FRAMEWORK

1.4 Research Foundation

1.4.1 RESEARCH OBJECTIVES

The main purpose of the study is to analyse strategic misalignment between the business dimension and information systems dimension. The research addresses misalignment symptom analysis by proposing an EA-based framework to detect the typical indicators of misalignment in an organisation. It aims to perform an EA-based, systematic analysis of mismatches between business and information systems domains. The main research objective lies in identifying general ways for detecting the symptoms of misalignment in the underlying EA models.

The main research objective strongly connects to the problem statement formed in the previous subsection. The sub-objectives of the above-introduced research objective consist in the breakdown of the main research objective into smaller, logically connected parts, viz.:

RO1:	WHAT ARE THE TYPICAL SYMPTOMS OF MISALIGNMENT ACCORDING TO THE OPERATION OF THE SAM MODEL?
RO2:	HOW TO TRANSFORM MISALIGNMENT SYMPTOMS INTO FORMALLY ANALYSABLE STATEMENTS?
RO3:	WHAT ARE THE FORMAL ANALYSIS METHODS OF DETECTING MISALIGNMENT SYMPTOMS IN ENTERPRISE ARCHITECTURE MODELS?

1.4.2 RESEARCH QUESTIONS

Based on expected outcomes and research objectives, the proposed research attempts to focus on the following research questions:

RQ1:	WHICH MISALIGNMENT SYMPTOMS CAN BE DETECTED VIA ENTERPRISE ARCHITECTURE ASSESSMENT?
RQ2:	WHICH DIMENSIONS AND DOMAINS ARE NEEDED TO EXAMINE IN AN EA MODEL TO DETECT MISALIGNMENT SYMPTOMS?
RQ3:	HOW DO EA MODELS MANIFEST DIFFERENT MISALIGNMENT SYMPTOMS?
RQ4:	WITH WHICH METHODS CAN WE EXPLORE THE DIFFERENT MISALIGNMENT SYMPTOMS IN EA MODELS?

1.4.3 RESEARCH MODEL

The proposed research aims to address the above-introduced research objectives and research questions by building a framework for EA-based misalignment symptom analysis. In this subsection, a concise introduction will be given on the chosen concepts and instruments to approach the research objectives. *Figure 1* introduces the conceptual research model of the study. In this Ph.D. dissertation, an analytical solution will be built to approach the topic of strategic alignment from an EA-based perspective. The problem of business-IT alignment will be translated into the aspects and analytical potential of enterprise architecture. The proposed research framework introduces an approach for EA-based alignment assessment, i.e. a solution for assessing alignment phenomenon in EA models. The research takes a rule-based approach to reveal the symptoms of malfunctioning alignment areas. The research steps are aggregated into three layers: 1) Misalignment Layer, 2) Enterprise Architecture Model Layer and 3) Analysis Layer.

Misalignment Layer is concerned with the construction and formal description of misalignment symptoms. Misalignment symptom construction is based on the matching of the SAM alignment domains. A formal description of misalignment symptoms consists of pattern generation.

EA Model Layer aims at preparing the underlying enterprise architecture models for misalignment symptom detection. The phase consists of model transformation, artefact decomposition, and export file generation.

Analysis Layer is concerned with the implementation details of the proposed research. EA-based misalignment symptom detection will be performed by means of formal rule testing, i.e. the analytical potential of rule generation and rule testing will be exploited. Misalignment symptoms will be defined as formal rules. After rule construction, rule testing approaches will be introduced.

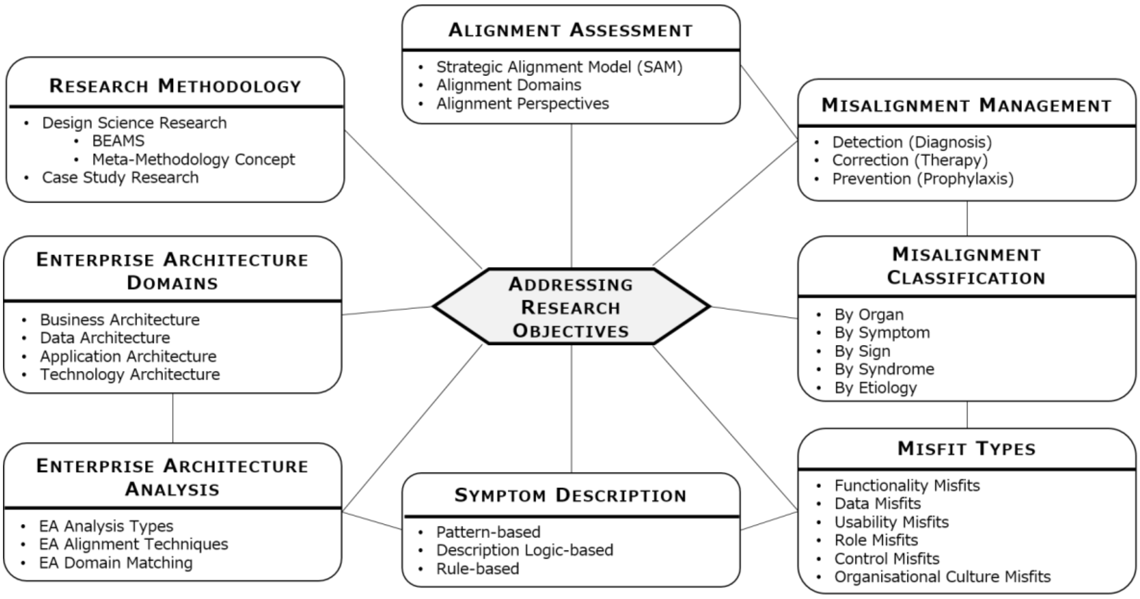

Figure 1. Conceptual Research Model

1.4.4 Summary of Research Methodology

The research aims to analyse the symptoms of misalignment via enterprise architecture assessment. The goal of the research is to create a framework that reveals the state and symptoms of misalignment in EA models.

The framework described in the subsequent parts of the dissertation is a well-structured, easy-to-use tool to support misalignment symptom detection. The structure of the framework is based on four main parts:

1) Alignment perspectives are used to structure the approach of misalignment symptom detection. Alignment perspectives are decomposed into constituent SAM domain matches.
2) A misalignment symptom catalogue is composed from symptom collections found in the recent literature on misalignment.
3) An artefact catalogue is introduced, which summarises potential containing EA models.
4) EA analysis catalogue describes potential EA analysis types that are suitable for revealing misalignment symptoms in containing EA models.

The proposed research methodology uses an alignment perspective-driven approach. In the first step, traditional alignment perspectives are provided with typical misalignment symptoms. In the second step, relevant artefacts are connected to the misalignment symptoms, which may contain the symptom in question. In the third step, suitable EA analysis types are recommended to the misalignment symptoms. These EA analysis types are able to detect the symptoms in the recommended containing artefacts.

In research design, the interactive model of Maxwell (1996) will be used. The structure of the proposed framework will reflect the recommendations of the model. As for methodological choices, the research will be based on the inductive approach and will use a qualitative methodology for data analysis. In addition, the research will utilise a mixed approach for framework building and validation. In this mixed approach, the Design Science Research and the Case Study Research methodologies will be mixed: Framework building will be supported by the Design Science Research methodology (Peffers et al., 2007), while empirical validation will be conducted using the Case Study Research method (Yin, 1994; 2013). The operation, as well as the correctness and relevance of the framework, will be validated via case studies. Different best of breed organisations will be examined in order to analyse their enterprise architecture models with the proposed framework. As a result, case studies will be created on the outcomes of the architecture assessments.

1.4.5 Summary of Research Results

The main objective of the proposed research lies in identifying ways for detecting the symptoms of misalignment in the underlying EA models. The sub-objectives break down the research objective into smaller, logically connected parts along the conceptual structure, i.e. misalignment symptom identification, formal description of misalignment symptoms and formal methods of EA analysis. This subsection summarises the research results of the following parts of the Ph.D. dissertation. To achieve the previously listed research objectives, the following results will be produced in the Ph.D. dissertation:

RO1: What are the typical symptoms of misalignment according to the operation of the SAM model?

>> Issue Covered by:

The framework will include a misalignment symptom categorisation according to the traditional alignment perspectives and alignment types in Section 3.5.2.

RO2: How to transform misalignment symptoms into formally analysable statements?

>> Issue Covered by:

Misalignment symptoms will be managed as formal rules. The proposed framework in Section 3.5 will process rules via XML validation techniques.

RO3: What are the formal analysis methods of detecting misalignment symptoms in enterprise architecture models?

>> Issue Covered by:

In Section 3.4 a concept categorisation will be presented on competing methods for EA-based misalignment symptom detection. In addition, the proposed framework in Section 3.5 will serve as a formal analysis method for the research topic.

Research objectives were broken down into analysable research questions in previous parts of the section. To address the above-introduced research questions, the following results will be delivered in the subsequent sections of the Ph.D. dissertation:

RQ1: Which misalignment symptoms can be detected via enterprise architecture assessment?

>> Solution Provided:

The proposed framework will consist of an assessment tool (Section 3.5.2, *Table 27*) for architecture-scope misalignment symptoms. Architecture-scope misalignment symptoms will be further examined in Section 3.5.2 for providing EA-based queries.

RQ2: Which dimensions and domains are needed to examine in an EA model to detect misalignment symptoms?

>> Solution Provided:

The proposed framework will consist of an assessment tool (Section 3.5.2, *Table 28*) for EA models and specific model elements to be investigated for misalignment symptom detection.

RQ3: How do EA models manifest different misalignment symptoms?

>> Solution Provided:

Listing specific model elements and pattern queries in Section 3.5.2, *Table 28* will provide tracking for misalignment symptom manifestation.

RQ4: With which methods can we explore the different misalignment symptoms in EA models?

>> Solution Provided:

A concept categorisation will be presented on competing methods for EA-based misalignment symptom detection in Section 3.4. In addition, the proposed framework will serve as a formal analysis method for the research topic.

The proposed research will produce structured data on the symptoms of misalignment. In a broad sense, the usage of the proposed framework will facilitate and ease the planning and evaluation of IT service portfolio in large, complex and heterogeneous organisations. The proposed framework will help organisations to correct these strategic and structural deficiencies by showing the content and the location of the mismatches found in their EA models. In addition, by formally analysing their EA models, organisations will also be able to reveal further operational characteristics that can be utilized as e.g. indicators for new strategic directions.

Expected outcomes of the research were listed in previous parts of the section. To summarise research outcomes of the Ph.D. dissertation, expected outcomes are contrasted with the research outcomes delivered in the subsequent parts of the Ph.D. dissertation. Expected outcomes of the proposed research will be covered by the following research outcomes of the Ph.D. dissertation:

EO1: CLASSIFICATION OF DIFFERENT MISALIGNMENT SYMPTOMS: EA INDICATORS ON MISALIGNMENT, EA DETECTION TECHNIQUES

>> Research Outcome:

A classification scheme will be served in Section 3.4 in terms of 1) EA-based indicators on misalignment and 2) EA-based misalignment symptom detection methods.

EO2: A FRAMEWORK WHICH CAN SUPPORT EA-BASED (MIS)ALIGNMENT ASSESSMENT

>> Research Outcome:

An EA-based misalignment assessment framework will be proposed in Section 3, which is able to reveal mismatches between the different alignment domains in the underlying EA models.

EO3: CASE STUDIES ON THE OPERATION, CORRECTNESS, RELEVANCE, ACCURACY AND RESULTS OF THE FRAMEWORK

>> Research Outcome:

Results will be produced in the form of a case study in Section 4. Case analysis will demonstrate the operation, correctness, relevance and accuracy of the framework.

1.4.6 Delimitations of the Study

Delimitations of the study contain both conceptual and methodological perspectives.

As for *conceptual limitations*, the research will not evaluate alignment maturity, nor soft alignment characteristics (e.g. organisational culture, HR aspects, etc.). It is known that not all misalignment phenomena can be detected via enterprise architecture assessment, e.g. corporate culture or shared values. In addition, due to the lack of documentation, several symptoms will stay hidden in EA models. Undocumented symptoms cannot be identified with the proposed framework. Regarding these limitations, the research does not aim to identify every misalignment symptom, but only those that can be detected via enterprise architecture models. Furthermore, misalignment assessment will not apply the steps of misalignment correction and prevention, nor other classification schemes except the symptom-based approach.

In terms of *methodological perspectives*, the proposed research will not utilise the benefits of cross-sectional case studies. Furthermore, the research instruments chosen in the dissertation will only be used for case study generation and analysis. Taking these limitations into consideration, the research aims to use the proposed framework 1) to detect different misalignment symptoms, 2) to indicate misalignment symptoms that cannot be detected via architecture assessment, and 3) to propose suggestions to solve the detected or indicated misalignments.

1.5 Acknowledgement

Firstly, I would like to express my gratitude to my supervisor, Zoltán Szabó, Ph.D. for his continuous support and motivation during my ongoing Ph.D. study.

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Last, but not the least, I thank my family and my closest friends for supporting me throughout my studies.

1.6 Organisation of the Study

The remainder of the Ph.D. dissertation is organised as follows:

- *Section 2 Review of the Literature* reviews existing literature on the research subject. After summarising search description basics, the theoretical foundation is given. It is followed by the introduction of the main component issues: 1) Strategic Alignment, 2) Alignment Assessment, 3) Misalignment, 4) Enterprise Architecture Management, 5) EA Analysis and 6) EA-based Alignment Assessment Methods.
- *Section 3 Research Methodology* introduces the research method by choosing and justifying its constituent parts. After introducing methodological choices, the proposed framework and the proposed research method are presented. In this subsection, an outline is given on the main research steps. The section ends with summarising implementation details of the proposed research framework.
- *Section 4 Case Study: Road Management Authority* discusses an empirical validation of the proposed research framework. The case study details case and project introduction, the presentation of EA model structure and a detailed analysis on misalignment symptom detection. At the end of the section, validation results are interpreted and discussion is presented on operating the proposed research framework.
- *Section 5 Conclusion and Summary* introduces conclusions together with a concise summary of contributions, expected research outcomes and research implications.
- At the end of the dissertation appendices and references are listed.

2 REVIEW OF THE LITERATURE

The theoretical foundation of the Ph.D. dissertation consists of 6 main parts. It commences with a summary of search description and search strategy. This subsection is followed by a succinct foundation for research contextualisation. After creating theoretical context, the literature review continues with an introduction on the main concepts of the proposed research. It commences with a wide-range introduction on strategic alignment. In this part, different alignment definitions, alignment dimensions, including well-known alignment models are presented. Special attention is paid to the well-known Strategic Alignment Model (SAM) (Henderson and Venkatraman, 1993). The strategic alignment subsection is followed by a brief introduction on misalignment. Different misalignment definitions, misalignment management strategies and misalignment assessment frameworks are presented in this section. Subsequently, enterprise architecture frameworks and domains are summarised. Finally, state of the art EA-based alignment methods are presented. Special attention is paid to the TOGAF framework (TOG, 2015). Different enterprise architecture analysis types, as well as EA alignment methods, are presented, which are more closely related to the proposed framework. To start with, *Figure 2* presents the constituent parts of the literature review.

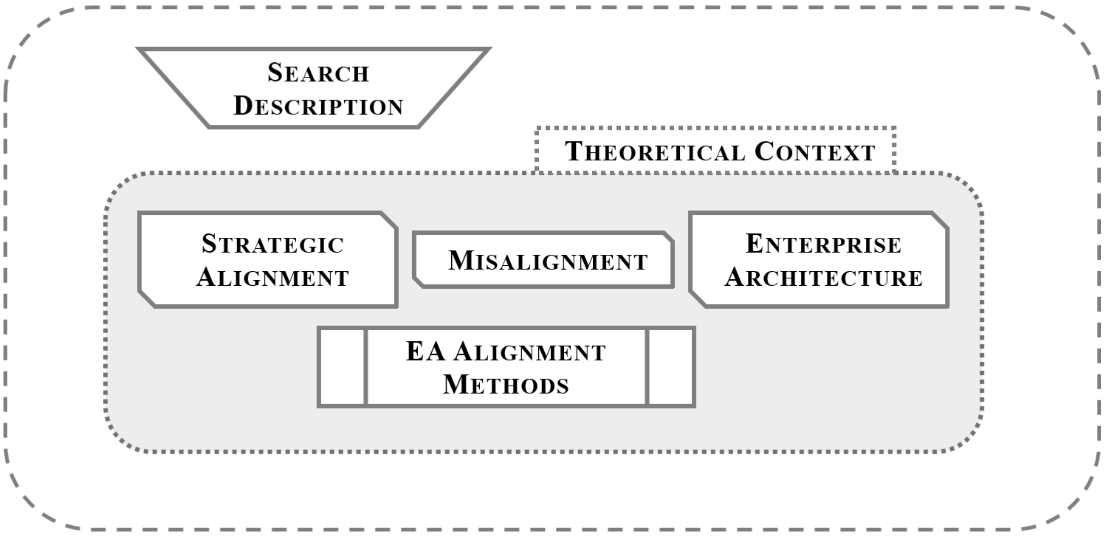


Figure 2. Components of the Literature Review

2.1 Search Description

In this subsection, criteria will be given for the selection of related literature resources and for the process of developing the review of literature. The purpose of the following literature review is to assess the state of the art in the research focus being investigated. It surveys the contributions of existing literature to the research subject under review. The literature review aims to outline existing knowledge on the selected research fields and presents the milestones of constituting research directions, i.e. to show how far researchers have reached in the research topic. The literature review also allows the researcher to identify any gap in the research area. Identified gaps provide a rationale for the proposed research direction and methodology (Webster and Watson, 2002).

A well-defined search strategy for retrieving relevant literature on the research topic consists of the following strategic choices and commitments (Dudley et al., 2004):

- Formulating a well-defined research question
- Indicating the scope and purpose of the review
- Identifying component issues
- Identifying primary keywords in the research topic
- Identifying alternative phrases or synonyms of the key topics
- Narrowing the search by pre-defined criteria, e.g. language, date type, type of publication
- Categorising positions taken in the research, e.g. in favor, against, alternative viewpoints

Additionally, criteria for identifying resources consist of the consideration of the following points (Dudley et al., 2004):

- Using multiple bibliographic databases
- Using bibliographies of existing literature reviews and state of the art articles
- Using conference proceedings for up to date research directions in the area
- Scanning key journals in the research topic
- Using a controlled vocabulary thesaurus to facilitate search retrieval by eliminating the use of different terminology for the same concept

Finally, inclusion–exclusion criteria are used to identify potentially relevant articles. Assessment of the literature includes some criteria taken into consideration for selecting from existing literature on the topic. Selection criteria for resources to be included/excluded in the literature review can be summarised as follows (*Table 1*):

Table 1. Selection Criteria for Resources to be Included/Excluded in the Literature Review (Dudley et al., 2004; Torraco, 2005)

CRITERION	INTERPRETATION
Provenance	List of the credentials of the author
Arguments supported by evidence	Usage of evidence, e.g. primary historical material, case studies, narratives, statistics, recent scientific findings
Objectivity	The author takes an even-handed approach; fair and impartial in treatment or judgment
Paper value	The paper contributes in any significant way to the understanding of the subject
Level of conviction	The paper contains convincing arguments and conclusions
Relevance	Relevance of the results to the topic being investigated
Recency	Up to date results delivered to the existing knowledge on the subject
Completeness	Level of completeness in terms of e.g. topic, structure, arguments, results, discussion, references

2.2 Theoretical Context

Search description is followed by a summary of theoretical context. The purpose of the Theoretical Context section is to contextualise and frame the research topic being investigated in the dissertation. This subsection creates a theoretical foundation for the research problem and prepares the context for 1) literature review topics, 2) research framework proposition.

The theoretical context part spans the areas of 1) Strategic Management of IT, 2) Enterprise Engineering and 3) Formal Methods for System Design. *Figure 3* illustrates the areas and subareas covered in the theoretical context section. It also contains assignments for literature review topics, i.e. which theoretical context areas drive to the literature review topic.

After succinctly framing theoretical context, the section continues with the main topics of the literature review: 1) Strategic alignment and alignment assessment techniques, 2) Misalignment assessment, 3) EAM and EA analysis methods, 4) EA-based alignment assessment frameworks.

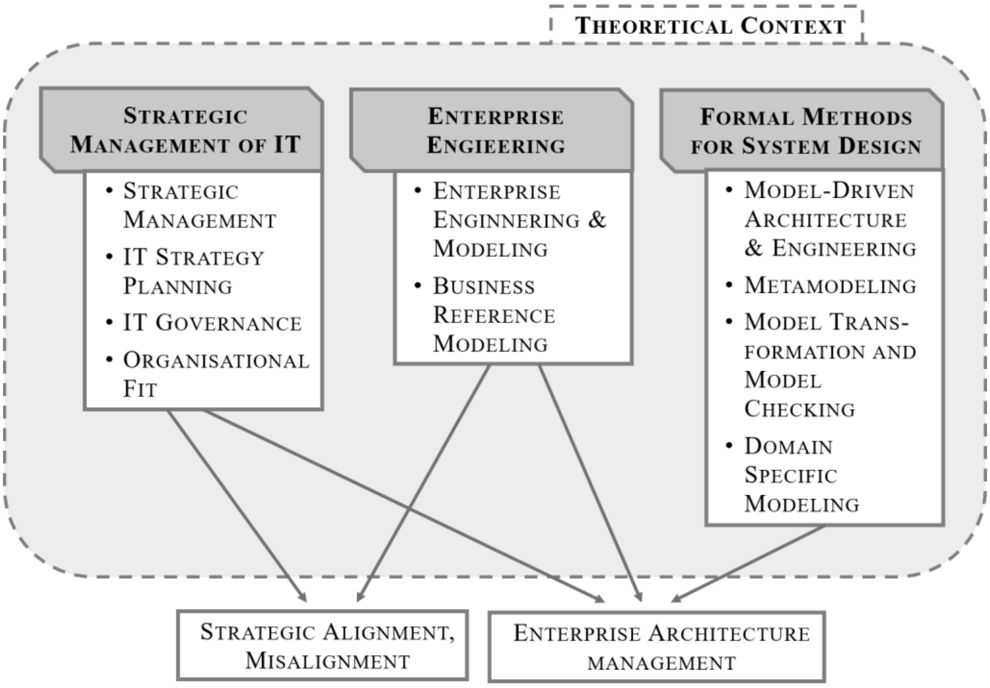


Figure 3. Theoretical Context and Assignments for Literature Review Topics

2.2.1 Strategic Management of IT

From a strategic management perspective, the proposed research builds on the topics of Strategic Management, IT Strategy Planning, IT governance and Organisational Fit. As for strategic management, the areas of strategy planning, schools of strategies (Mintzberg, 2005), strategic choices and options (Doyle, 1990) and strategic management frameworks (awareness frameworks, opportunity frameworks, positioning frameworks) (Hall, 1993) are referred to as basic concepts. These traditional topics are still generating considerable interest in terms of general strategic management and the strategic management of IT as well. As for the strategic management of IT, the influential grouping of Earl (1989; 1993; 1994) (IS strategy, IM strategy, IT strategy) and techniques of IT strategy planning (e.g. the 7S Model, CCTA approach, Business Systems Planning, Strategic Systems Planning, IT landscape management, Zachman Framework) (IBM, 1981; Lederer and Sethi, 1988; Zachman, 1982; 1987) have to be noted as basic concepts. Subsequently, one of the pillars of IT governance (De Haes and Van Grembergen, 2004; Weill and Ross, 2004) is strategic alignment, which is set to become a vital factor in managing IT governance. The topic of strategic management of IT brings us to the concepts of strategic alignment and enterprise architecture. Additionally, the concept of organisational fit and different fit models (e.g. Strong and Volkoff, 2010) also lead us to the topic of strategic alignment and are attracting considerable interest too. Topics in this section will serve as theoretical highlights and contextual boundaries of the proposed research framework.

2.2.2 Enterprise Engineering

From an engineering perspective, the proposed research builds on the topics of Enterprise Engineering (EE) and Enterprise Modelling (EM). Enterprise Engineering (Hoogervorst, 2009; Dietz et al., 2013; De Vries et al., 2014) is considered as a sub-discipline of industrial / systems engineering. Two types of EE have been developed: 1) General EE, which is concerned with engineering and management of enterprises and 2) Specific EE, which is concerned with software engineering and enterprise modelling. The former brings us to the concept of strategic alignment, while the latter leads us to enterprise architecture. EE methods include e.g. UML and Petri Nets. Enterprise Modelling (Vernadat, 2002; Scheer, 2012) has its origins from systems modeling and information systems modeling. Enterprise Modelling consists of 1) Function Modelling, 2) Data Modelling, 3) Business Process Modelling and 4) Systems Modelling. EM techniques include several methods (e.g. BPMN) and metamodelling frameworks (e.g. GERAM). One of the techniques of EM is enterprise architecture. Business Reference Modelling (BRM) (Fettke and Loos, 2006; Becker et al., 2007) is considered as a related field of EM. A business reference model is part of an EA framework, so the concept of BRM leads us to enterprise architecture. Other related fields of EM include economic modeling, system thinking and ontology engineering (Uschold, 1998; Dietz, 2006; Dietz and Hoogervorst, 2008). Topics of enterprise engineering lead us to the phenomena of strategic alignment and enterprise architecture. The areas listed in this section will serve as the methodological basis of the proposed research framework.

2.2.3 Formal Methods for System Design

From the perspective of formal methods, the proposed research builds on the topics of Model-Driven Architecture and Engineering, metamodeling, model transformation, model checking, modeling languages and Domain Specific Modelling. In summary, these areas bring us to the concept of enterprise architecture and to the constituent parts of the proposed research methodology. Model-Driven Architecture (MDA) and Model-Driven Engineering (MDE) are considered as approaches for software design. MDA was launched by the Object Management Group (OMG), while the acronym MDE (Schmidt, 2006; Kent, 2002) is used to refer to general model engineering areas. MDA (Frankel, 2003; Kleppe et al., 2003; Mellor, 2004) uses a domain specific language from the concept of Domain Specific Modeling (DSM) (Kelly and Tolvanen, 2008; Gray et al., 2007; France and Rumpe, 2005). Related standards include e.g. UML, MOF, and XMI. Metamodeling (van Gigch, 1991; 2013; Kühne, 2006) is referred to as a process of creating models of a model and includes the analysis, construction, and development of theories, rules and constraints for generating metamodels. Types of modeling languages include e.g. domain specific languages (van Deursen and Klint, 2002) and architecture description languages (ADL) (Medvidovic and Taylor, 1997; 2000). Model transformation (Mens and Van Gorp, 2006; Czarnecki and Helsen, 2003) is considered an especially important area of MDA. An influential standard in the field of model transformation is QVT (Stevens, 2007). Finally, model checking (Clarke et al., 1994; 1999; Baier et al., 2008) is referred to as the check whether a model of a system meets a previously given specification. The introduced topics of formal methods for system design will serve as the technical background for elaborating research methodology and developing the proposed research framework.

2.3 Strategic Alignment

This subsection introduces the main concepts of strategic or business-IT alignment. Firstly, motivation, alignment definitions, and drivers are given. It is followed by a summary of influential alignment models, with special attention to the well-known Strategic Alignment Model (SAM). The subsection concludes with possible categorisations for alignment types, alignment dimensions, and alignment levels.

Business-IT alignment is regarded as one of the most important issues in information systems research since information systems foster the successful execution of business strategies. Organisations aim to align their business and IT for several reasons, e.g. using IT effectively to accomplish their business goals, utilising the ability of IT to create business value, or integrating IT into their business strategy, mission, and goals (Chan and Reich, 2007). Strategic alignment is referred to as an ideal situation in which organisations use appropriate IT instruments which provide congruency with their business strategy. Alignment is considered as 1) the degree of fit between business and IT strategy and infrastructure, as well as 2) the level of how IT strategy can support the business strategy. Business-IT alignment takes place if the organisational goals and activities are in harmony with the supporting information systems (Luftman and Brier, 1999). The first mention of the need for business-IT alignment were given by McLean and Soden (1977) and Henderson and Sifonis (1988). These early studies referred to alignment as 1) the linking of business and IT plans or 2) establishing the congruence of business strategy with IT strategy and vice versa, 3) investigating the relation between business needs and IS priorities. These perspectives of alignment resulted in the strategic use of IT and led to higher performance (Chan et al., 2006).

Alignment has different definitions in literature. Henderson and Venkatraman (1993) define alignment as a degree of fit between business and IT strategy, as well as business and IT infrastructure. Reich and Bensabat (1996) conceptualise the term alignment as the level of how IT strategy can support the business strategy. Sauer and Yetton (1997) point out that IT is a mirror for business management. Luftman and Brier (1999) argue that alignment is the situation when organisations apply appropriate IT that is congruent with business strategy.

The following phrases are considered equivalent terms of alignment:

- fit (Chan, 1992; Henderson and Venkatraman, 1993),
- linkage (Reich, 1993),
- integration (Henderson and Venkatraman, 1993),
- bridge (Ciborra, 1997),
- harmony (Luftman et al., 1999) and
- fusion (Smaczny, 2001).

Drivers of alignment consist of both foreground and background aspects. Foreground antecedents (i.e. visible behaviours which influence alignment) are e.g. leadership methods, planning methods, communication styles or successful top manager relationships between business and IT (Baker, 2004; Feeny et al., 1992; Lederer and Mendelow, 1989; Cragg et al., 2002; Teo and Ang, 1999). Background antecedents include e.g. corporate culture, shared knowledge, corporate vision, the strategic role of IT (Reich and Benbasat, 2000; Chan et al., 2006; Brown and Magill, 1994).

Outcomes of alignment include several aspects, e.g. 1) increase of organisational performance (Floyd and Woolridge, 1990; Powell, 1992; Cragg et al., 2002), 2) shift in industry performance, 3) descriptively, i.e. presenting the value of IT (Henderson and Venkatraman, 1992), 4) prescriptively, i.e. suggesting potential courses of actions (Henderson and Venkatraman, 1992) and 5) dynamically, i.e. indicating aspects to be addressed over time (Henderson and Venkatraman, 1992).

Alignment models are holistic approaches which can be used in a prescriptive manner, i.e. they prescriptively define the method of achieving and sustaining the state of alignment. Various approaches have been proposed to introduce a method for this issue. Although there are several alignment models in the literature, some models are particularly influential and recognized, such as the MIT Model (Scott Morton, 1991), the MacDonald Model (1991), the Baets Model (Baets, 1992), the Amsterdam Information Model (AIM) (Maes, 1999; Maes et al., 2000) and Henderson and Venkatraman's Strategic Alignment Model (SAM) (1993). *Figures 4-6* represent the Baets Model, the MIT Model, and the AIM Model respectively.

Alignment models have been gaining much attention due to their further applicability. Much research has extended the SAM model, e.g. Luftman et al. (1993), Goedvolk et al. (1997), Avison et al. (2004).

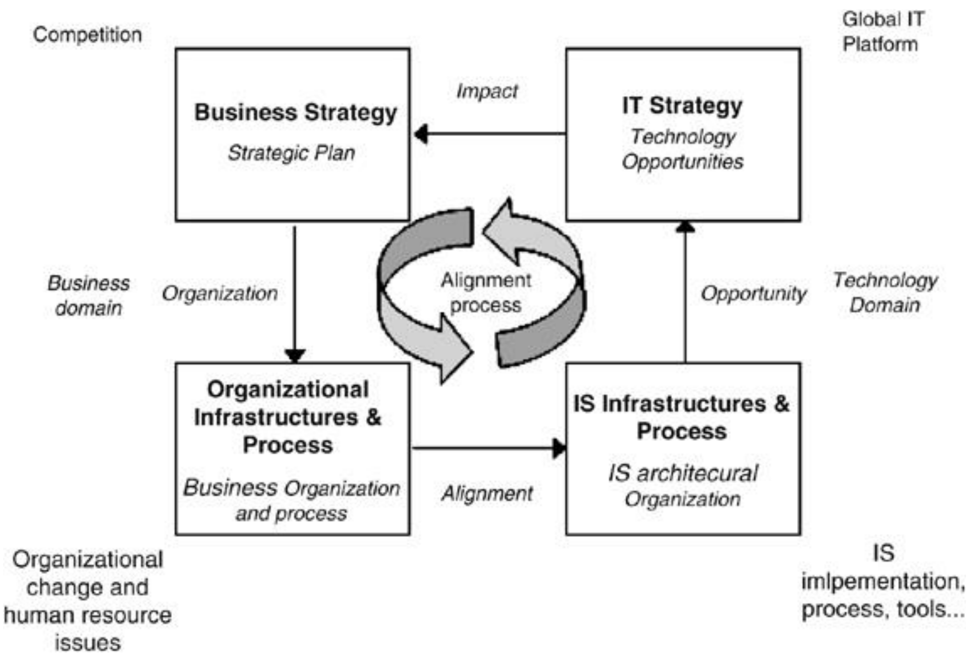


Figure 4. Baets Model (Baets, 1992)

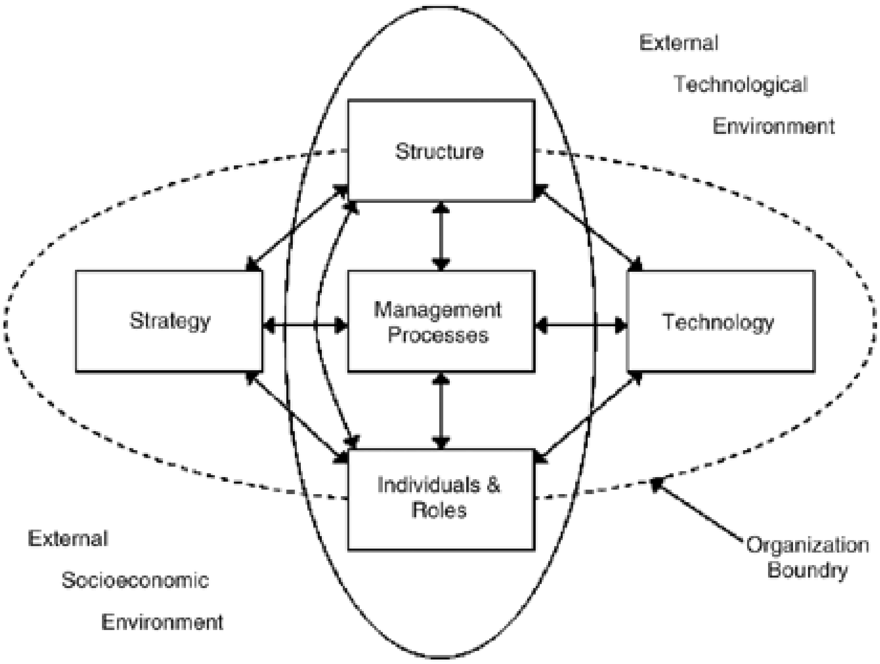


Figure 5. MIT Model (Scott Morton, 1991)

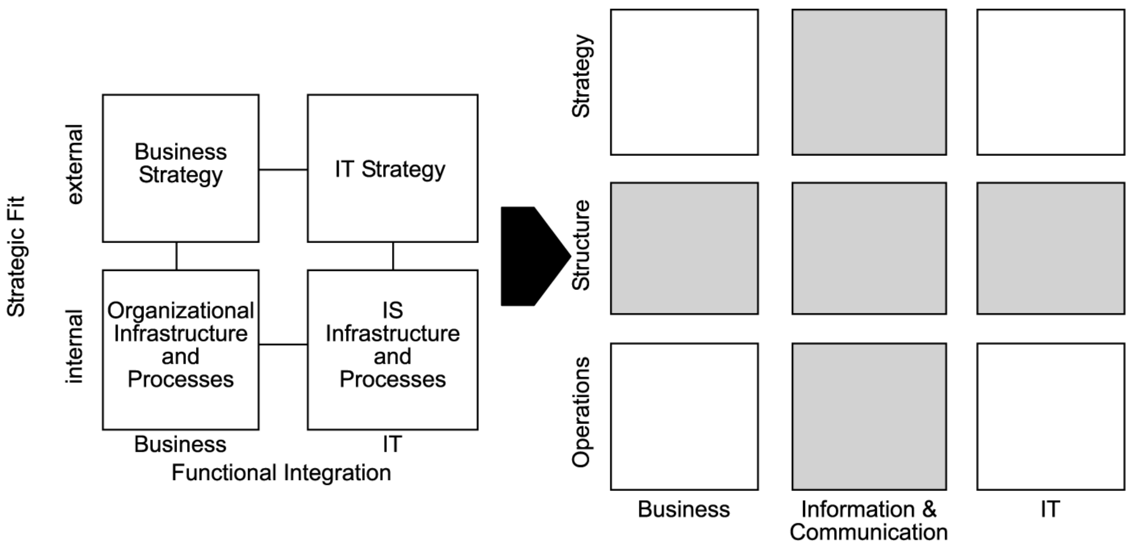


Figure 6. AIM Amsterdam Information Model (Maes et al., 2000)

The SAM model can be referred to as the most cited alignment model in literature. The model has four key domains of strategic choice (a.k.a. alignment domains): 1) Business Strategy, 2) Organisational Infrastructure and Processes, 3) IT Strategy and 4) IT Infrastructure and Processes. The external axis of the model consists of the business and IT strategy domains, while the internal axis contains organisational and IT infrastructure and processes. Business axis refers to business strategy and business structure, while IT axis consists of IT strategy and IT structure. The model is based on two primary building blocks: 1) strategic fit and 2) functional integration (Henderson and Venkatraman, 1993). The strategic fit dimension means the need to align the external and internal domains of IT, while functional integration consists of the need to integrate business and IT domains. *Figure 7* introduces the traditional SAM model. Further analysis on the operation of the SAM model will be proposed in the following subsections.

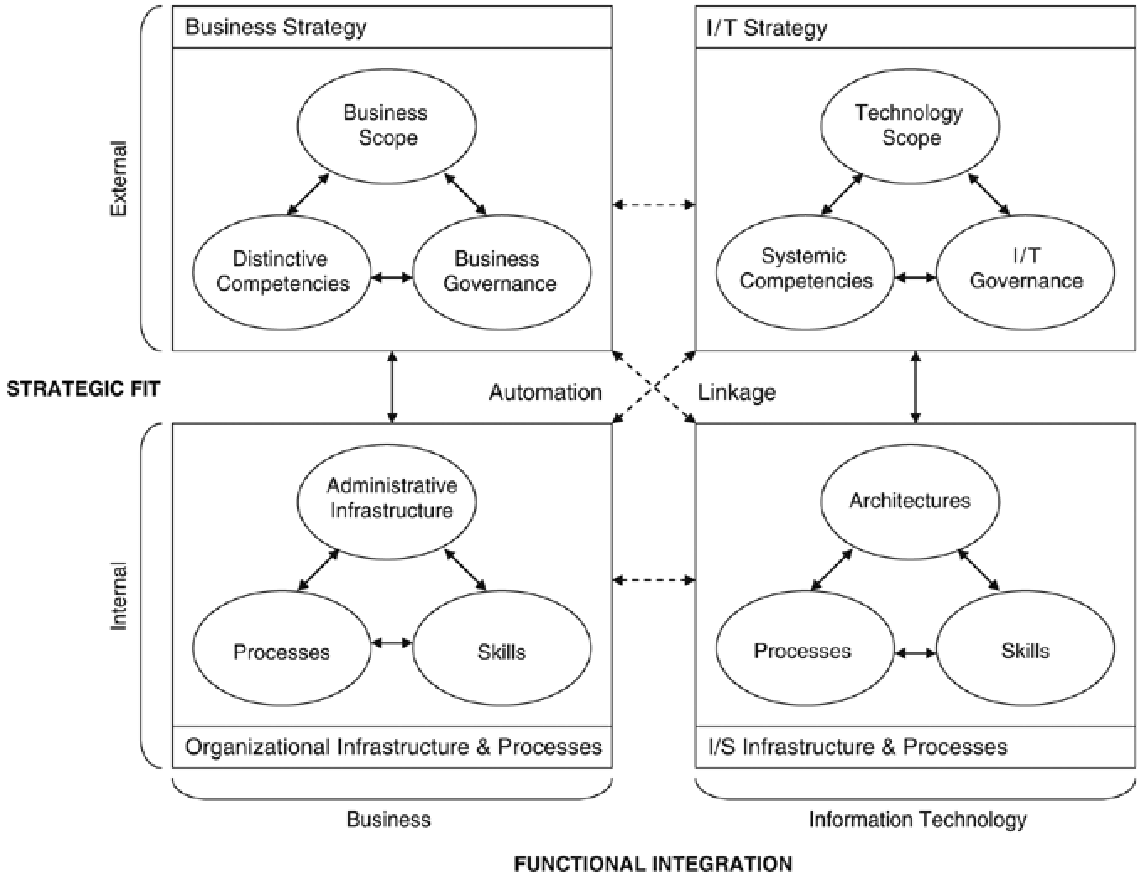


Figure 7. Strategic Alignment Model (SAM) (Henderson and Venkatraman, 1993)

For alignment type categorisation several approaches can be used. Firstly, matching different SAM domains results in 6 different alignment types (Sabherwal et al., 2001):

1) *Business alignment*: business transformation, the matching of business strategy and organisation infrastructure and processes
2) *Strategic alignment*: business products and services, the matching of business strategy and IT strategy
3) *Structural alignment*: information system products and services, the matching of organisation and IS infrastructure and processes
4) *IT alignment*: technology transformation, the matching of IT strategy and IS infrastructure and processes
5) and 6) *Cross-dimensional alignments*: the matching of business strategy and IS infrastructure and processes and IT strategy and organisation infrastructure and processes

Figure 8 illustrates the 6 alignment types according to the corresponding SAM domain matches.

Another classification for alignment types provides alignment dimensions. This classification results in 1) Structural, 2) Functional, 3) Socio-cultural, 4) Infological and 5) Contextual alignment dimensions. *Figure 9* illustrates alignment dimensions proposed by Reich and Benbasat (1996), Magoulas et al. (2012) and Chan (2001).

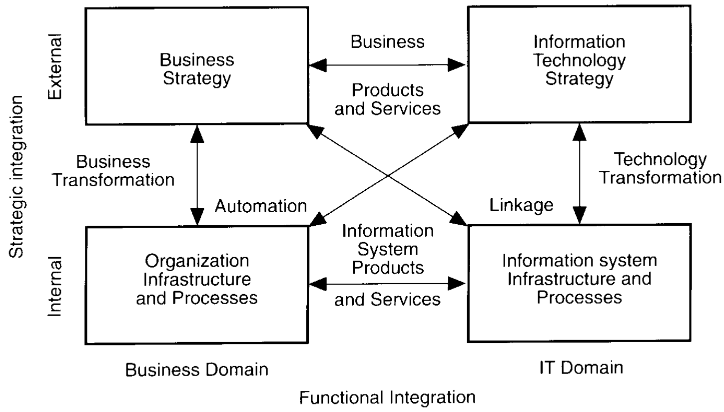


Figure 8. Alignment Types according to the Strategic Alignment Model (Henderson and Venkatraman, 1993; Sabherwal et al., 2001)

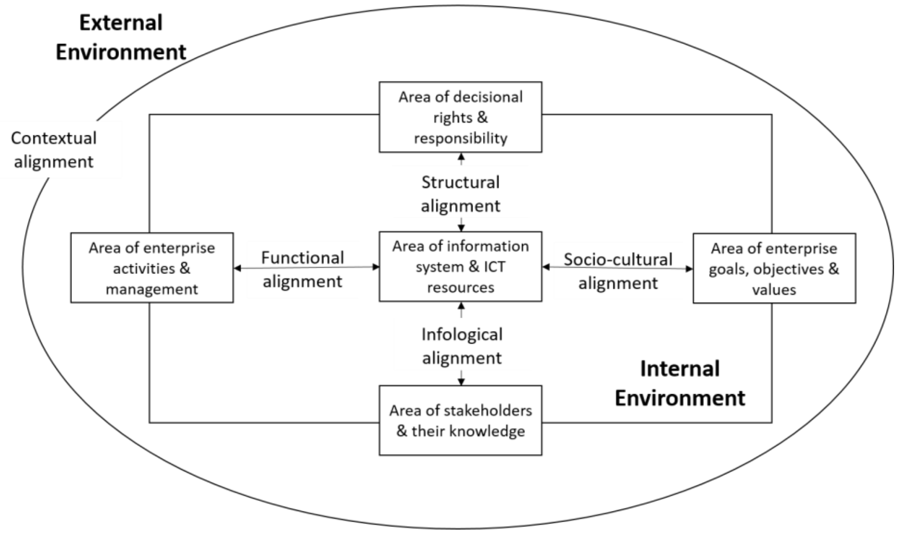


Figure 9. Alignment Dimensions (Reich and Benbasat, 1996; Magoulas et al., 2012; Chan, 2001)

Alignment dimensions approach the alignment issue in different ways (Reich and Benbasat, 1996; Chan, 2001, 2002):

- *Strategic dimension* of alignment means the degree to which business strategy and IT strategy are connected to each other.
- *Structural dimension* of alignment refers to the business – IT structural fit.
- *Informal dimension*: Informal structures are relation-based structures in an organisation. Informal dimension transcends the formal structure (e.g. division of labor, coordination of tasks); in this dimension business and IT are aligned via informal lines.
- *Social dimension* of alignment means the state in which business and IT units understand each other and are committed to the business and IT strategies and goals.
- *Cultural dimension* refers to the cultural elements of alignment, such as business planning style, communication style, and common language.

Alignment level categorisation refers to the organisational areas where alignment should be present. In an ideal situation alignment is present at all levels of organisations, including 1) at the organisational level, 2) the system level (Floyd and Woolridge, 1990; Campbell, 2005), 3) project level (Jenkin and Chan, 2006), and 4) individual/cognitive level (Tan and Gallupe, 2006).

Taking the internal and external domains of alignment into consideration, there are additional alignment categorisations:

- For *internal domains*, Earl (1989) states the need for aligning IT strategy and infrastructure with information systems strategy (i.e. applications and information) in an organisation.
- For *both internal and external domains*, Henderson and Venkatraman (1993) recommend that alignment should be both internal and external to the organisation. External alignment means the alignment of business and IT strategies with industry and technology forces. Internal alignment refers to the organisational and IT processes and infrastructure.
- For *external propositions*, Sledgianowski and Luftman (2005) propose the need for leveraging IT assets on an enterprise-wide basis. It is performed in order to extend the reach of the organisation into supply chains of customers and suppliers. Additionally, Galliers (2004) recommends that alignment should also effect and be effected by external partners (e.g. customers and suppliers).

In conclusion, several categorisations may be given for business-IT alignment. In this research, the concepts of the SAM model will be utilised extensively. In addition, alignment types will be used for classifying different symptoms of malfunctioning structures. Alignment dimensions and alignment levels will frame research context and will serve as possible tools for delimiting the proposed research framework.

2.4 Alignment Assessment

General introduction on strategic alignment is followed by a summary of influential alignment assessment methods. In this subsection the concept of strategic alignment perspectives, the process models of alignment and alignment approaches are detailed. The section concludes with critical success factors and challenges of alignment, which lead us to the following concept, the phenomenon of misalignment.

There are four dominant alignment perspectives, so-called cross-domain relationships in the SAM: 1) Strategy Execution, 2) Technology Transformation, 3) Competitive Potential and 4) Service Level (Henderson and Venkatraman, 1993). Alignment perspectives cover 3 out of 4 alignment domains in order to define directions for alignment domain analysis. Every alignment perspective consists of 2 alignment domain matches, a.k.a. perspective components. *Figure 10* shows traditional alignment perspectives. The figure may be interpreted as follows: Anchor means that the perspective is driven by that particular domain. Every perspective affects two additional domains, the intermediate domain is called pivot area, while the ending point is considered the area of impact.

Strategy Execution perspective deals with the supporting role of IT concerning business strategy-based business structure. Business strategy is translated into business processes and infrastructure to which IT processes and infrastructure provide appropriate support. The perspective is business strategy-driven, which means that if there is a change in business strategy direction, business structure is changed accordingly. In this case, IT structure must be able to adapt to renewed business structure via modified supports (Henderson and Venkatraman, 1993).

Technology Transformation perspective is concerned with the business value of IT. In this perspective, IT provides innovative solutions in response to the business goals. Innovative possibilities are divided into IT processes and infrastructure which enable the implementation of the innovative solutions. In this perspective, business structure does not constrain the implementation of the innovative solution (Henderson and Venkatraman, 1993).

Competitive Potential perspective is about emerging information technologies which are able to provide new possibilities to the business. These new concepts affect the business strategy, through which new business structure will be developed. In this perspective, IT provides new distinctive competencies to the business. Business strategy is built according to the potentials provided by IT. The perspective helps to exploit emerging IT capabilities in order to be able to develop new business products and services (Henderson and Venkatraman, 1993).

Service Level perspective deals with different ways through which IT can improve business service, or IT can deliver the necessary capabilities to support business products and services. Service Level perspective is intended for implementing an IT service-based organisation. Service levels are defined by collaboration between business and IT. The IT service centre operates according to the contracted service levels (Henderson and Venkatraman, 1993).

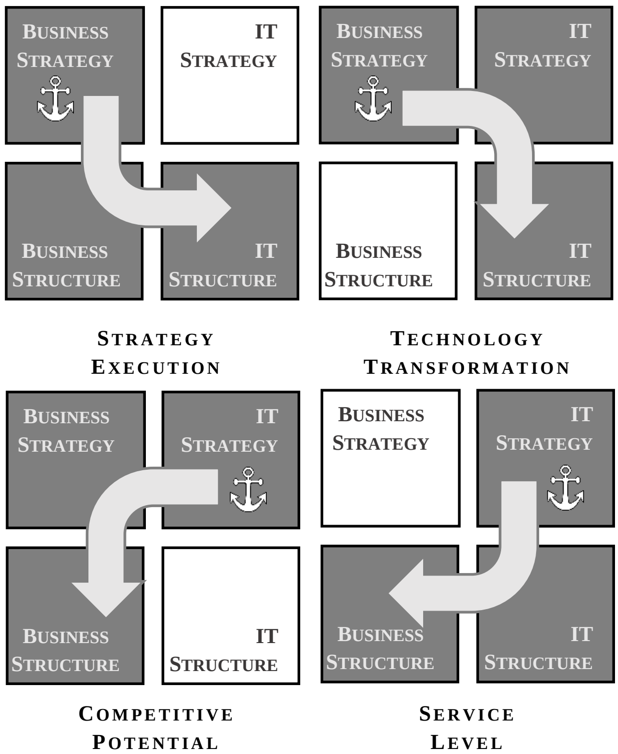


Figure 10. Traditional Alignment Perspectives (adapted from Coleman and Papp, 2006; Henderson and Venkatraman, 1993)

The SAM model introduced only four dominant alignment perspectives out of the 8 possible perspectives. The 4 additional perspectives (Organisation IT Infrastructure, Organisation Infrastructure Strategy, IT Organisation Infrastructure and IT Infrastructure Strategy, see *Figure 11*) are presented and analysed by Coleman and Papp (2006).

Besides additional alignment perspectives, Coleman and Papp (2006) also presented a concept for alignment fusions. In this approach, two alignment perspectives are combined and taken simultaneously. A combination of alignment perspectives, a.k.a. alignment fusions may be found in the study of Coleman and Papp (2006). *Figure 12* shows two examples of alignment fusions.

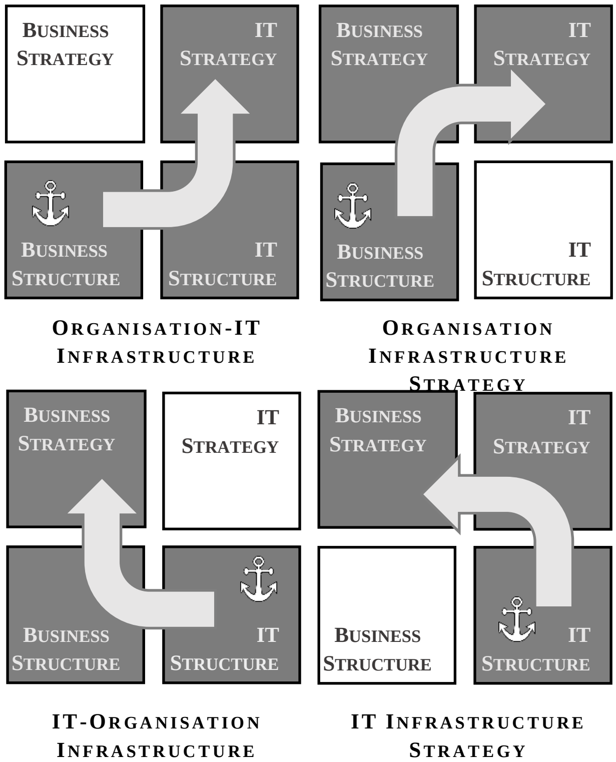


Figure 11. Additional Alignment Perspectives (Coleman and Papp, 2006)

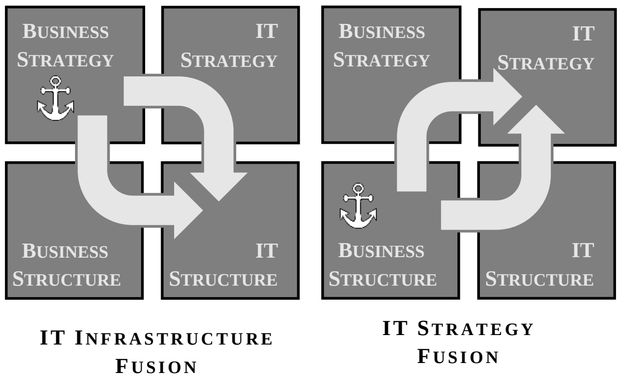


Figure 12. Examples of Alignment Combinations, a.k.a. Alignment Fusions (Coleman and Papp, 2006)

Process models of alignment are based on two schools of thought that were established regarding alignment (Whittington, 1993). 1) Processual vs classic schools of thought in which the former concentrates on internal and power issues, while the latter focuses on a model of rational adaptation. 2) Continuous management of organisational components (i.e. continual calibration of certain elements in the organisational model) (Baets, 1996; Luftman and Brier, 1999; Rondinelli et al., 2001; Sledgianowski and Luftman, 2005).

Process models of alignment accent the process-like nature of alignment (vs. end state). Several process models of alignment deal with the evolution of alignment (i.e. how alignment has changed over time). These models include e.g. the 'stages of growth' model (Burn, 1993; Street, 2006), the 'lead-lag' model (Burn, 1996; 1997) or the 'punctuated equilibrium' model (Sabherwal et al., 2001). The Strategic Alignment Process (SAP) presented by Scott Morton (1991) introduces a process for establishing and assessing alignment. *Figure 13* illustrates the operation of Strategic Alignment Process.

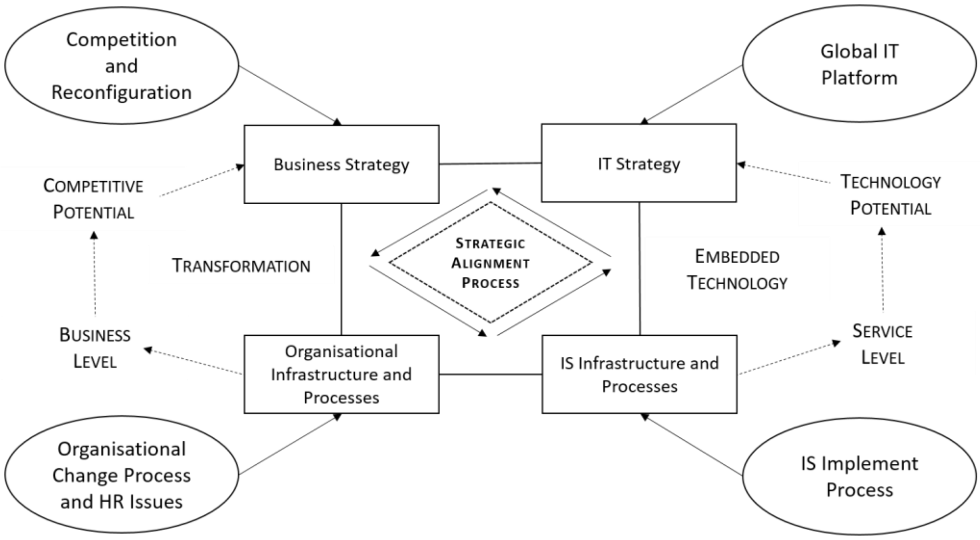


Figure 13. Strategic Alignment Process (Scott Morton, 1991)

In literature there are several examples of alignment assessment methods. Many attempts have been made in order to classify and analyse alignment evaluation techniques. In general, alignment can be measured by different approaches, including e.g. typologies and taxonomies, fit models, mathematical calculations, survey items, qualitative assessments and psychological measures (Chan and Reich, 2007). In recent years a growing body of literature has examined alignment evaluation methods.

A recent review of literature on this subject was carried out by Doumi et al. (2011b). It provided a comparison of possible alignment evaluation approaches. In this comparison, different approaches were summarised as well as limitations of the proposed approaches were detailed:

- Approach of EA (Zachman, 1987)
- Approach of Urbanization of Information System (Longépé, 2001)
- Approach of Modeling and Construction of Alignment Oriented Needs (Bleistein, 2006)
- Approach of Evaluation and Evolution of Strategic Alignment (Luftman, 2000)
- Approach of Modeling and Construction of Alignment between the Environment, Processes and the Systems – SEAM (Wegmann et al., 2005, 2007)
- Approach of Evaluation of the Degree of Alignment of the Business Process and Information System – ACEM (Etien, 2006)
- Approach of Evaluation of the Degree of Alignment between the Couple Strategy of the Enterprise and (Business Process, Information System) – INSTAL (Thevenet et al., 2009)
- Approach Oriented Values: E3 Values (Gordijn and Akkermans, 2003)

Table 2 describes and compares alignment approaches according to the aspects of alignment entity under review, modeling levels, modeling types, and methods in use for construction, evaluation, and correction of alignment.

In addition, there are also additional alignment assessment methods, which were not included in the comparison of alignment approaches. Other approaches include e.g. the plugIT approach

(Woitsch and Utz, 2009), the ServAlign approach (Ghose et al., 2013), the REFINTO framework (Umoh et al., 2012) and the ALBIS framework (Cruz-Cunha, 2013).

Most of the introduced approaches for alignment measurement build on strategic and/or functional level assessment and include top-down construction approach. Modeling structures of these studies incorporate some feasible and applicable methods (e.g. Goal Modelling, Ontology) which will also be listed in the possible implementation directions subsection. On the other hand, the minority of the cited approaches deal with the evaluation and correction of alignment, which significantly decreases the applicability of these methods for misalignment assessment.

Table 2. Comparison of Alignment Approaches (based on Doumi et al., 2011b)

Criterion / Study	Align-ment entity	Modeling levels	Construc-tion of Alignment	Modeling	Evalua-tion of Align-ment	Correc-tion of Align-ment
Luftman, 2000	Strategy/ IT	…	…	…	None	None
Zachman, 1987	Enterprise strategy and IT, BP, System, Environ-ment, etc.	…	…	Artefact classification	None	None
Bleinstein, 2006	Strategy/ Business process	Strategy	Top-Down	Goal Modelling (I*)	None	None
Wegmann et al., 2005, 2007	Environ-ment/ Business process	Functional	Top-Down	…	None	None
Etien, 2006	Business process/IS	Functional	Top-Down	Ontology	Yes	None
Longépé, 2001	Strategy/IS	Functional	Top-Down	…	None	None
Gordijn and Akkermans, 2003	Strategy/ business, process, IT	Strategy/ Functional	Top-Down	Goal Modeling/ Business Model	None	None
Thevenet et al., 2009	Strategy/ business process, IS	Strategy/ Functional	Top-Down	Card Formalism	None	None

To conclude alignment assessment methods, the section ends with some aspects on critical success factors and typical challenges of alignment achievement. This summary on success factors and difficulties will lead us to the second main construct of the literature review, to the phenomenon of misalignment.

There have been many attempts in recent alignment literature to propose success factors of alignment achievement. Several lists are available on critical success factors of alignment (e.g.

Burn and Szeto, 2000; Teo and Ang, 1999). To give some examples, CSFs of alignment include e.g. 1) choosing an appropriate alignment approach (Burn and Szeto, 2000), 2) the commitment of top management to the strategic use of IT (Teo and Ang, 1999), 3) the confidence of top management in IT (Teo and Ang, 1999), 4) the efficiency and reliance on IT services (Teo and Ang, 1999), and proper communication between business and IT (Teo and Ang, 1999). Many studies have been published on alignment success factors. CSFs have been receiving much attention due to its role in achieving and sustaining alignment.

Finally, there is a vast amount of literature on typical alignment challenges. Most of them list challenges around alignment achievement, e.g. the lack of organisational commitment towards alignment and missing documentation of organisational strategy, mission, and goals (Baets, 1996; Reich and Bensabat, 2000). Chan and Reich (2007) propose a categorisation scheme for difficulties that might be encountered while achieving alignment. According to their proposal, challenges in attaining alignment can be categorised into three groups: 1) Challenges related to knowledge, 2) Challenges related to the locus of control, 3) Challenges related to organisational change. *Table 3* summarises some of the challenges in attaining alignment according to their categorisation scheme.

Table 3. Sample Challenges in Attaining Alignment (Chan and Reich, 2007)

CHALLENGE CATEGORY	CHALLENGE EXAMPLES
Challenges related to knowledge	▪ Unknown corporate strategy (Reich and Bensabat, 2000) ▪ Lack of awareness or belief in the importance of alignment (Baets, 1996) ▪ Lack of industry and business knowledge (Baets, 1996)
Challenges related to the locus of control	▪ The status of IT (Campbell et al., 2005)
Challenges related to organisational change	▪ Response to organisational change (Van Der Zee and De Jong, 1999)

In this research, misalignment assessment will be based on traditional alignment assessment techniques. Strategic alignment perspectives will be used for driving misalignment symptom categorisation. The Strategic Alignment Process will serve as a tool for tracking misalignment symptoms in EA models over time. The proposed research reflects various alignment approaches from the above-introduced alignment evaluation toolset. CSFs and challenges of alignment will be utilised in misalignment symptom generation.

2.5 Misalignment

To investigate the state of business-IT alignment in an organisation, two general perspectives can be considered, 1) to analyse its presence (alignment assessment) or 2) analyse its absence or deficiencies (misalignment assessment) (Chan and Reich, 2007; Carvalho and Sousa, 2008). The common way of evaluating the state of business-IT alignment is alignment evaluation, which analyses the presence of this phenomenon. In the case of analysing its absence or deficiencies, misalignment assessment is conducted. The innate need for analysing misalignment has already been mentioned by Chan and Reich (2007) in their high-profile literature review on business-IT alignment.

In this subsection, the concept of misalignment will be introduced. After collecting drivers and motivation of the misalignment phenomenon, the section commences with definitions on misalignment. It is followed by a summary of influential misalignment models and processes. In this part, special attention is paid to the symptoms of misalignment. Recent literature on misalignment symptom catalogue and categorisation schemes are examined at the end of the section.

While organisations are continually trying to achieve alignment, they are suffering from difficulties which encumber the achievement of alignment. This observation points out the phenomenon of misalignment, which is referred to as the "opposite" of strategic alignment, i.e. when strategy, structure, processes and technology are not perfectly harmonised. Most traditional alignment studies deal with alignment achievement, while misalignment issues are scarcely covered in literature. However, organisations are in the state of misalignment as long as they achieve (or at least approach) the state of alignment. This fact indicates that considerable attention should be paid to the phenomenon of misalignment. Misalignment analysis is an important step in achieving alignment since it helps to understand the nature and the barriers of alignment. In addition, it supports organisations in proposing certain steps to re-achieve alignment.

To give a decent definition on misalignment, several approaches were studied. The different views on the topic resulted in different definitions, which will be showed hereafter.

- The state of business-IT alignment can be analysed either through its presence (alignment) or through its absence or deficiencies (misalignment). In this sense, misalignment can be referred to as a state when organisations fail to achieve or sustain alignment (Carvalho and Sousa, 2008). This definition stresses that misalignment is an undesired state that must be avoided or corrected.
- Another perspective declares that misalignments are different problems occurring while an organisation is trying to achieve alignment. According to this concept, misalignments are aggravating circumstances. If we accept that alignment is the desired state of an organisation, we define misalignments as complicating factors with which organisations are facing while achieving alignment (Carvalho and Sousa, 2008).
- Chen et al. (2005) state that misalignment is any business process that is not appropriately aligned with the requirements.

To sum up the different views on misalignment definition a collection of general misalignment characteristics is given. According to the different definitions, it can be stated that:

- misalignment has an innate negative connotation,
- alignment and misalignment are antonyms,
- misalignment must be eliminated and substituted with alignment,
- misalignment is a difficulty that impedes alignment,
- misalignment indicates a disorder in the operation of the organisation.

There are several misalignment models mentioned in literature. The very first mention of misalignment was conducted by Luftman (2003), who collected a set of misalignment symptoms. The relevance of this work was twofold, 1) it declared that misalignment can be detected by its symptoms; 2) it stated that misalignment inhibits the achievement of alignment. The next relevant work on misalignment was conducted by Pereira and Sousa (2004). They gave a summary of key issues concerning Business-IT Alignment. In their work, they identified misalignment as one of the key alignment concerns. Additional frameworks on misalignment included different aspects regarding misalignment. Fritscher and Pigneur (2011) proposed a business model ontology for misalignment identification. Zarvic and Wieringa (2006) introduced the GRAAL framework (Guidelines Regarding Architecture Alignment). Sia and Soh (2007) presented the so-called Sia-Soh model, while Strong and Volkoff (2010) proposed a categorisation for misfit types. The most famous misalignment models are the BISMAM model (Business and Information Systems MisAlignment Model) by Carvalho and Sousa (2008) and the BITAM method (Business IT Alignment Method) by Chen et al. (2005).

The BITAM approach gave the first structured conceptualisation on misalignment. It dealt with business and IT architecture misalignment management. It was an engineering-principled misalignment detection and correction method which set up 12 steps to detect and correct misalignment.

The BISMAM model gave special attention to the handling of misalignment. In the model, an analogy was shown in which a medical sciences approach was used to set up misalignment nomenclature. The model introduced misalignment from a medical science perspective, using the analogy of detecting, correcting and preventing illnesses. The approach defined a basis for misalignment classification and misalignment techniques, based on detection, correction and prevention steps.

Since misalignment is a non-desired state, organisations aim to eliminate it. Organisations can avoid this condition by detecting, correcting and preventing misalignment(s). The triad of 1) detecting, 2) correcting and 3) preventing misalignment(s) is the general process of handling the phenomenon (Chen et al., 2005; Carvalho and Sousa, 2008).

- *Misalignment detection* means the diagnosis of this undesired state. It includes the processes of a) misalignment identification and b) symptom analysis.
- *Misalignment correction* is the process of realigning business processes with information systems. The correction step is about terminating the symptoms by correcting the malfunctioning procedures.
- *Misalignment prevention* is the process that helps to avoid the state of misalignment. Prevention means an array of activities with which the non-desired condition can be avoided. Prevention includes detection and correction skills as well.

Problems, complicating factors and aggravating circumstances that occur while organisations are trying to achieve alignment are considered the indicators of misalignment. To classify these indicators, several approaches can be taken, categorising e.g. by organs, by signs, by syndromes or by symptoms. Carvalho and Sousa (2008) provide different classification schemes for the indicators of misalignment. *Table 4* describes these classification schemes.

While organisations are trying to achieve alignment, different problems, complicating factors and aggravating circumstances are occurring. Misalignment symptoms are considered evidence of inefficiencies, difficulties or inabilities that encumber alignment achievement. The existence of these symptoms demonstrates the state of misalignment in an organisation. Misalignment symptom detection deals with the identification of such indicators. Matching the domains of the SAM results in general types of misalignment symptoms. *Figure 14* illustrates some examples of symptom groups between different SAM domain matches.

Table 4. Classification Schemes for Misalignment Indicators (Carvalho and Sousa, 2008)

CLASSIFICATION CATEGORY	DESCRIPTION
by Organ System	Organisation components involved in misalignment
by Symptom	Evidence experienced by business actors
by Sign	Evidence experienced by external and internal business actors
by Syndrome	Set of symptoms and/or signs that frequently occur together
by Etiology	Underlying causes that induce misalignment

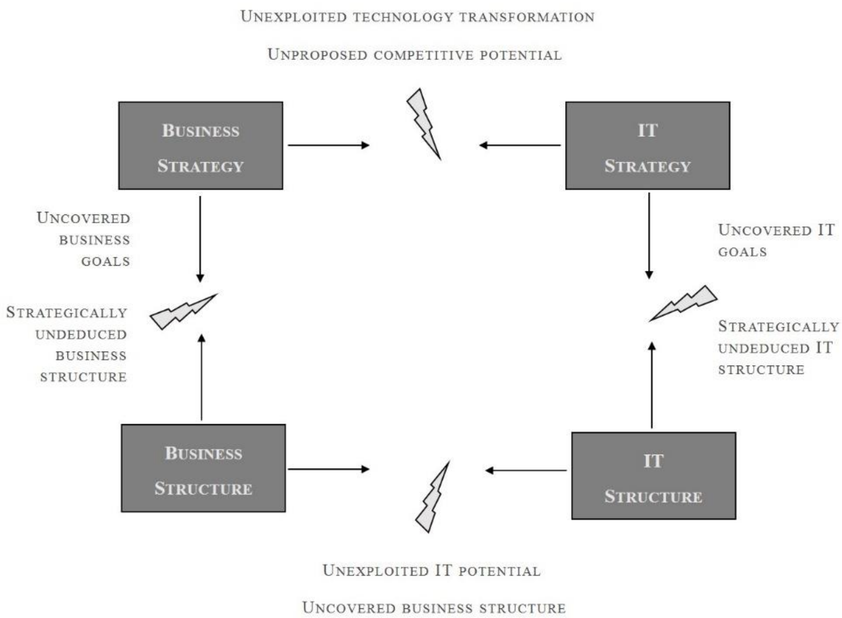


Figure 14. Matching of SAM Domains Results in General Types of Misalignment Symptoms

To approach misalignment phenomena in a more practical manner, the introduction continues with some examples. *Table 5* shows some explanatory misalignment symptoms. These evidence can demonstrate the state of misalignment in an organisation.

Table 5. Explanatory Misalignment Symptoms (proposed by Carvalho and Sousa, 2008)

MISALIGNMENT SYMPTOM
Undefined organisational strategy and organisational goals
Undefined business process goals
Undefined security requirements over the information entities
Users managed differently in different applications
Undefined capacity and performance requirements
Lack of data ownership
Multiple hierarchy or lines of reporting
Lack of application interfaces
Multiple applications managing the same information

Several misalignment symptom collections have been proposed in recent literature on misalignment. These collections contain different types of misalignment symptoms. Some of them will be able to be detected via EA-based techniques, others will not be applicable in the proposed framework. The former type of symptoms will be subsequently used in the proposed framework. The latter type of symptoms will be omitted since these types of symptoms consist of rather soft signs (communication, governance), or even too technical signs. Luftman (2000) proposed an alignment maturity framework in which several signs of malfunctioning structures are presented. In this maturity framework, misalignment symptoms are categorised into criteria, e.g. symptoms related to communication, governance or partnership. Most of these symptoms are considered soft factors for (mis)alignment assessment, e.g. symptoms related to governance structure, skills or partnership between business and IT. Luftman (2003) presented a list of typical misalignment symptoms perceived by organisations. Most of these symptoms can be referred to as typical symptoms for covering business-IT relationship and traditional alignment areas, e.g. alignment satisfaction, missing skills and competencies, conflicts between the business and IT side. Carvalho and Sousa (2008) proposed a shortened and also an extended list of misalignment signs and symptoms. The symptoms listed in these contributions are considered well-structured and easy-to-handle symptoms for EA-based misalignment assessment. Pereira and Sousa (2005), as well as Sousa et al. (2005), listed typical alignment heuristics. In their approach, heuristics are presented according to EA domain matches, e.g. alignment between business architecture and information architecture layers, alignment between information architecture and application architecture layers, etc. These symptoms are related to technical problems between architecture layers, rather than specific alignment problems between these layers. However, these lists contain several potential symptoms for EA-based assessment. *Appendix B* lists the complete misalignment symptom catalogues found in recent studies on misalignment.

Misalignment symptoms can be categorised via different approaches. Luftman (2000) proposes an alignment assessment framework in which the categorisation of 1) Communications, 2) Competency/Value Measurements, 3) Governance, 4) Partnership, 5) Scope & Architecture and 6) Skills is given. These areas of alignment assessment can also be used for misfit classification, i.e. misalignment symptoms can be classified into these categories. Misalignment symptoms can also be classified via different misfit categorisations. Strong and Volkoff (2010) provide a possible categorisation scheme by classifying misalignment symptoms into 1) Functionality, 2) Data, 3) Usability, 4) Role, 5) Control and 6) Organisational Culture misfit types. Saat et al. (2010) propose a classification by IT system and business categories. In their scheme, the IT system category consists of 1) interoperability, 2) availability, 3) security, 4) usability and 5) accuracy groupings, while the business category consists of 1) efficiency and 2) effectiveness aspects. Finally, the alignment perspectives of the SAM model (Henderson and Venkatraman, 1993) can also be used as a classification scheme for misalignment symptoms. In the proposed framework the categorisation of traditional alignment perspectives will be used.

To sum up, the proposed research will extensively utilise the technique of misalignment detection. The research framework will reflect the recent studies of misalignment models and processes, especially the concepts of BISMAM and BITAM approaches. The proposed misalignment assessment framework will use a symptom-based method. A misalignment symptom catalogue will be generated from recent literature on misalignment symptoms. Finally, traditional alignment perspectives will serve as a symptom categorisation scheme.

2.6 Enterprise Architecture Management

Literature summary on strategic alignment and misalignment is followed by a succinct introduction to enterprise architecture management. After giving a definition for EA and EAM, motivation, drivers and well-known EA frameworks are presented briefly. Special attention is paid to TOGAF architecture framework. The section concludes with some details on EA modeling, tool support for EA and EA modeling languages.

Architecture is regarded as the fundamental structure of a system, including its components and their relationships. It is a formal description which also shows the main architectural principles and guidelines that facilitate the construction and operation of the system. In this respect, enterprise architecture (EA) is the construction of an enterprise, described by its entities and their relationships. EA is an organising logic for business processes and IT infrastructure in order to review, maintain and control the whole operation of an enterprise. This organising logic acts as an integrating force between business planning, business operations and enabling technological infrastructure. Enterprise architecture integrates information systems and business processes into a coherent map. Enterprise architecture supports IT strategy, IT governance and business-IT alignment (Zachman, 1987). It also helps to capture a vision of the entire system in all its dimensions and complexity (TOG, 2015). Enterprise architecture is a structure which helps, 1) coordinate the many facets that make up the fundamental essence of an enterprise and 2) provide a structure for business processes and supportive information systems (TOG, 2015).

Enterprise architecture management is a management philosophy concerned with corporate change. Factors leading to the need for strategic EAM can be summarised as follows (Ahlemann et al., 2012; Lankhorst, 2013; Schekkerman, 2004): 1) The fact that adaptation to the changing environment means a competitive factor. 2) The observation that poorly coordinated changes generate risks and paralyze business. 3) The perception that complex enterprise architecture increases costs and risks, and decreases flexibility and transparency. *Table 6* summarises different conceptualisations of EAM.

Table 6. Different Conceptualisations of EAM (Ahlemann et al., 2012)

CONCEPT	INTERPRETATION
EAM as a management philosophy	A holistic way to understand, plan, develop and control an organisation's architecture
EAM as an organisational function	A supportive function to enable and improve existing strategy planning and strategy implementation processes
EAM as a methodology	A set of management practices that helps to improve the quality of decision-making
EAM as a culture	An open approach to reach consensus among managers on the basis of their shared vision of establishing a global optimum for the firm, free of local and personal egotism and opportunism

Enterprise architecture management provides instruments to maintain the above-mentioned concerns. It helps to improve an enterprise's performance. The management of enterprise architecture results in increased transparency, documented architecture vision and clear architecture principles and guidelines. These factors contribute to efficient resource allocation, the creation of synergies, better alignment, and reduced complexity. In the end, better business performance can be achieved by using the EAM concept. EAM promotes the vertical integration between strategic directions and tactical concepts, design decisions, and operations. Additionally, it provides horizontal alignment between business change and technology. In addition, EAM improves the capability of an enterprise for perceiving, analysing and responding to organisational changes. It helps 1) to align the organisation with strategic goals, 2) to coordinate interdependencies in business and IT, 3) to prepare an organisation for an agile reaction. EAM plays a role in strategy formulation as well. Strategic EAM helps 1) to analyse the current situation, 2) assess strategic options, 3) formulate strategic initiatives, 4) develop an architectural vision, 5) roadmap migration activities, 6) assess and prioritise project portfolio and 7) monitor architecture evolution (Ahlemann et al., 2012; Lankhorst, 2013).

In order to cope with architecture complexity, different frameworks, methods, and tools have been developed. An enterprise architecture framework is a collection of descriptions and methods to create and manage enterprise architecture. Several enterprise architecture frameworks are available, e.g. the IEEE Standard 1471-2000 (Maier et al., 2001), the Zachman Framework (Zachman, 1987), the TOGAF framework (TOG, 2015) or the DODAF framework (DOD, 2009). The most recognised frameworks are the Zachman Framework (for rather theoretical purposes) and the TOGAF framework (for rather practical usage). The development of EA frameworks started in the 1980s. *Table 7* summarises the key milestones in the development of EA frameworks.

Table 7. Key Milestones in the Development of EA Frameworks (Ahlemann et al., 2012)

Release Date	EA Framework
1987	Zachman Framework
1989	NIST Enterprise Architecture
1991	Technical Architecture Framework for Information Management (TAFIM)
1992	Spewak's Enterprise Architecture Planning (EAP)
1996	▪ The Open Group Architecture Framework (TOGAF) ▪ Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR)
1997	Treasury Information System Architecture Framework (TISAF)
1999	Federal Enterprise Architecture Framework (FEAF)
2000	Treasury Enterprise Architecture Framework (TEAF)
2002	Federal Enterprise Framework (FEA)
2003	▪ The Department of Defense Architecture Framework (DoDAF) ▪ Extended Enterprise Architecture Framework (E2AF)

EA frameworks have developed from various sources. *Table 8* demonstrates some examples of these various sources together with EA framework examples.

The most commonly used EA frameworks are the Zachman Framework and the TOGAF Framework. While the Zachman Framework is defined as a taxonomy for organising architectural elements, TOGAF is a process-oriented EA framework which breaks an EA into different EA layers.

Table 8. The Most Established EA Frameworks (Ahlemann et al., 2012; Schekkerman, 2004)

TYPE	EA FRAMEWORK
Enterprise-developed Frameworks	▪ The Open Group Architecture Framework (TOGAF) ▪ Generalized Enterprise Reference Architecture and Methodology (GERAM) ▪ Reference Model of Open Distributed Processing (RM-ODP) ▪ Guide to the Enterprise Architecture Body of Knowledge (EABOK)
Commercial Frameworks	▪ Integrated Architecture Framework (IAF) ▪ Zachman Framework ▪ Architecture of Integrated Information Systems (ARIS) ▪ OBASHI Business & IT methodology and framework (OBASHI)
Defence Industry Frameworks	▪ Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) ▪ Department of Defence Architecture Framework (DoDAF) ▪ NATO Architecture Framework (NATO) ▪ Technical Architecture Framework for Information Management (TAFIM) ▪ UK Ministry of Defence Architecture Framework (MODAF) ▪ International Defence Enterprise Architecture Specification (IDEAS)
Government Frameworks	▪ Federal Enterprise Architecture Framework (FEAF) ▪ Government Enterprise Architecture (GEA) ▪ Treasury Enterprise Architecture Framework (TEAF) ▪ NIST Enterprise Architecture (NIST) ▪ Treasury Information System Architecture Framework (TISAF)
Other Frameworks	▪ Extended enterprise architecture framework (E2AF) ▪ Spewak's Enterprise architecture planning (EAP)

Zachman's well-known framework (Zachman, 1987) is considered to be a logical structure of an enterprise. It represents the whole enterprise in descriptive building blocks. It is an evolving framework: in its latest version, an enterprise ontology was introduced. The main advantages of this framework are that it is quite easy to understand and it is independent of methodologies.

TOGAF (The Open Group Architecture Framework (TOG, 2015)) is a commonly used architecture framework. It is a holistic approach which describes a metamodel for enterprise architecture and proposes different methods for building and maintaining enterprise architectures. The framework has four main components, 1) Architecture Capability Framework, 2) Architecture Development Method (ADM), 3) Architecture Domains and 4) Enterprise Continuum. The latter consists of different reference models (e.g. Technical Reference Model, Standards Information Base, The Building Blocks Information Base). The core of the TOGAF approach is the Architecture Development Method (ADM), which proposes an iterative method for developing and managing enterprise architecture. It consists of 10 phases. Phase B-D cover the four architecture domains (1-4), respectively. Architecture domains are considered different conceptualisations of an enterprise. TOGAF provides 4 architecture domains: 1) Business Architecture, 2) Data Architecture, 3) Application Architecture and 4) Technology Architecture. In their approach, Business Architecture is served by Data, Application and Technology Architectures. *Figure 15* shows the main structure of the architecture domains according to the TOGAF framework.

Figure 15. Architecture Domain Structure according to TOGAF (based on TOG, 2015)

TOGAF metamodel is a reference model which sets up the formal structure of an EA model as well as provides implementation guidance on core building blocks and their relationships. The metamodel depicts the core entities of the 4 architecture domains. Entities are connected to each other within and between architecture domains. Business Architecture is primarily connected with the other 3 architecture domains via Business Service. Business Service is, therefore, a bridge between several entities, refracting the direct routes between the different items (TOG, 2015). *Figure 16* depicts the TOGAF metamodel. In addition, TOGAF defines several views for describing EA. *Table 9* shows TOGAF views with the concerns addressed in each view.

The general introduction on TOGAF is followed by some details on EA modeling, tool support for EA and modeling/description languages. EA modeling deals with transforming real world concepts into an as-is or to-be phase EA model. According to Lankhorst (2013), EA modeling has three dimensions: 1) external or internal, 2) behavior or structure, 3) individual or collective.

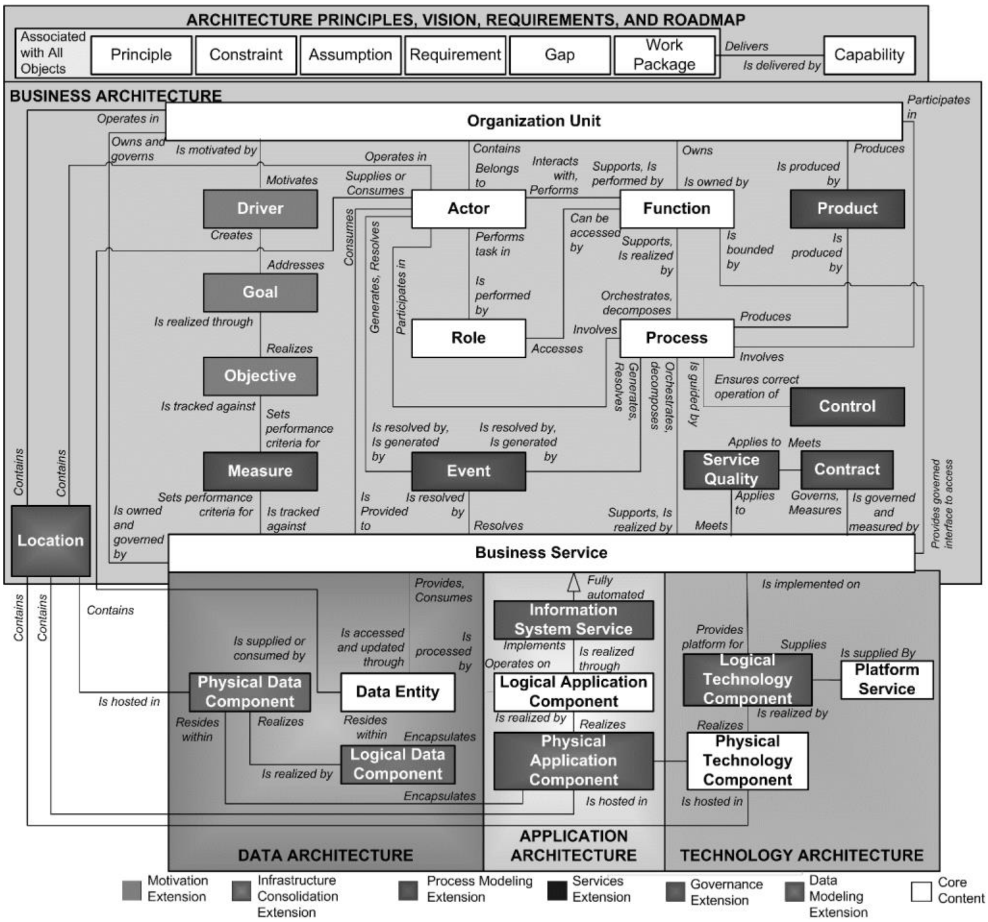


Figure 16. TOGAF Metamodel (TOG, 2015)

Table 9. TOGAF Views with Addressed Concerns (TOG, 2015)

VIEW	ADDRESSED CONCERNS
Business Architecture View	People, Process, Functionality, Business Information, Performance
Enterprise Security View	Security, Protection of information
Software Engineering View	Development approach, Software modularity and re-use, Portability, Migration, and Interoperability
System Engineering View	System requirements
Communications Engineering View	Technology requirements
Data Flow View	Organisational Data Use, Data Storage, Data Retrieval, Data Processing, Data Security
Enterprise Manageability View	Security, Software, Data, Computing/Hardware, Communications
Acquirer View	Cost, Standards

EA modeling works with a layer-concept, i.e. describes EA in different EA layers. Typical layers of an EA model are business, organisation, and processes, information systems (including applications, data and integration) and IT/IS infrastructure. A business process-based example illustrates the collaboration of different layers and constituent modeling objects in *Figure 17*.

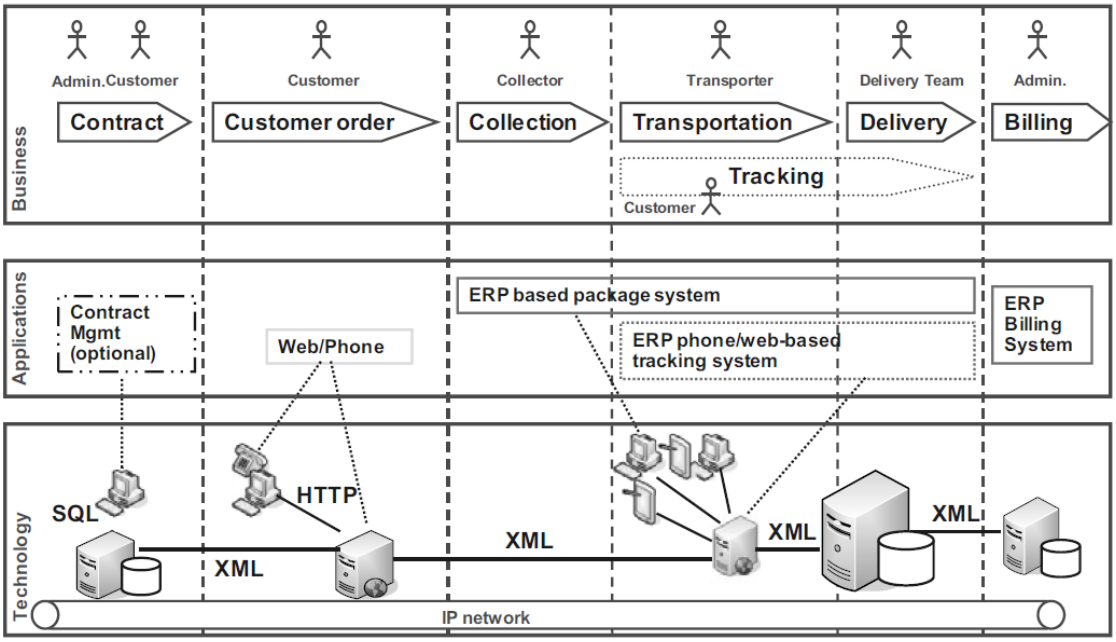


Figure 17. An Example of EAM Modelling (Ahlemann et al., 2012)

EA tools support the generation and management of EA models. Ahlemann et al. (2012) proposes qualities of EA tools by the need for 1) Meeting different stakeholder needs, 2) Providing user-friendly model development interface, 3) Providing support for automation, 4) Supporting extensibility and customisation, 5) Providing support for analysis and reporting, 6) Providing a robust yet flexible repository, 7) Offering good value for money and sufficient vendor support. *Table 10* gives an overview of popular EA tools:

Table 10. List of Popular EA Tools (based on Ahlemann et al., 2012 and Schekkerman, 2004)

Vendor	Tool
alfabet AG	planningIT
BOC Information Technologies Consulting GmbH	ADOit, Adonis
IBM	WebSphere Business Modeler
Software AG	ARIS Platform
iGrafx	Enterprise Modeler
MEGA International GmbH	MEGA Modelling Suite
Troux Technologies Inc.	Troux 7.1

Techniques and languages for describing information systems can be classified into three groups (Bernus et al., 2013): 1) Data and object modeling languages, 2) Activity and process modeling languages and 3) Multi-view languages. Data and object modeling languages are used for the modeling of the information view. They contain the information that is stored or processed by the information system during its life-cycle. Activity and process modeling languages are used for specification, design and implementation purposes. Multi-view languages are used for the representation of different views. They serve the needs of multiple modeling levels. Examples of description languages are IDEF, BPMN, Testbed, ARIS, Unified Modelling Language (UML) and Architecture Description Languages (ADL) (Lankhorst, 2013). ADL – IEEE 1471 standard provides a conceptual model for architecture description (see *Figure 18*):

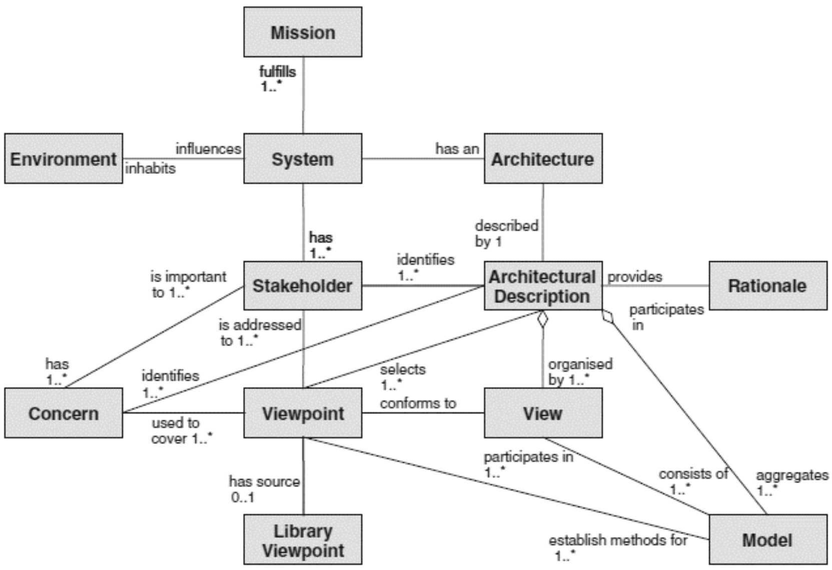


Figure 18. Conceptual Model of Architecture Description (Lankhorst, 2013) by the IEEE 1471–2000/ISO/IEC 42010 Standard (Maier et al. 2001)

ArchiMate is a common language for EA modeling developed by The Open Group (AMS, 2012). ArchiMate contains layer metamodels for business, application and technology layers. Layer content is classified into core and extension building blocks. Core contents contain business, application and technology layer concepts. Extension contents contain the concepts of 1) Motivation Extension and 2) Implementation & Migration Extension. ArchiMate uses several viewpoints. Core viewpoints include Introductory, Organisation, Actor Cooperation, Business Function, Product, Service Realisation, Business Process Cooperation, Business Process, Information Structure, Application Cooperation, Application Usage, Application Behaviour, Application Structure, Infrastructure, Infrastructure Usage and Implementation & Deployment viewpoints. Extension Viewpoints include: 1) Stakeholder, Goal Realisation, Goal Contribution, Principles, Requirements Realisation and Motivation viewpoints for Motivation Extension and 2) Project, Migration and Implementation and Migration for Implementation & Migration Extension. ArchiMate also matches layer metamodels which result in 1) Business Layer and Lower Layers Alignment and 2) Application-Technology Alignment.

In the proposed research, the concepts of TOGAF will be used for EA-based misalignment symptom analysis. In particular, the partition of architecture domains and the TOGAF metamodel will be utilised. Nevertheless, the research framework will also reflect the concepts of EA modeling and modeling/description languages.

2.7 EA analysis

In this subsection, different techniques will be introduced for EA analysis. Firstly, phenomena of architecture principles and architecture patterns will be summarised. The section continues with a broader summary of the artefact approach of TOGAF. Subsequently, EA analysis techniques are presented from recent literature. The section concludes with tool support for EA analysis.

Architecture principles and patterns are used for framing the architecture content (Pessi et al., 2011; Proper and Greefhorst, 2010). Architecture principles are explicitly defined values, decisions about the structure and content of the EA. Architecture patterns are harvested from best practices attempting to describe the successful implementation of a solution in a particular context (Kotzé et al., 2012). The context of architecture principles is summarised in *Figure 19*.

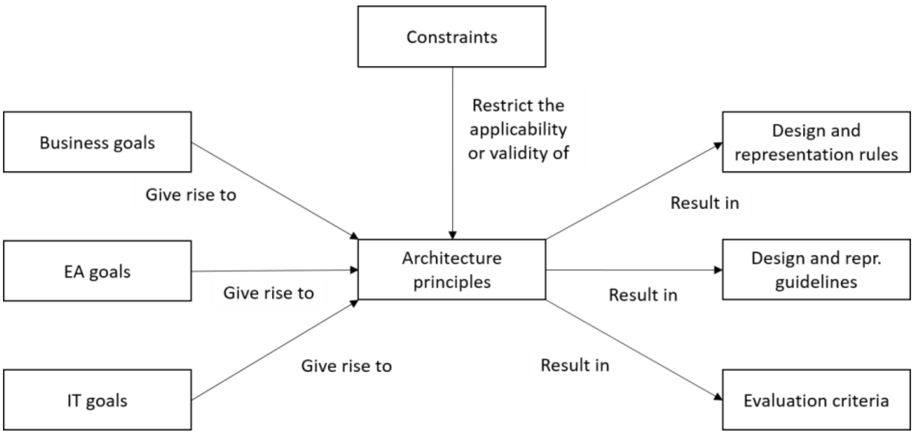


Figure 19. The Context of Architecture Principles (Proper and Greefhorst, 2010)

Pattern collections are referred to as the container of patterns, which manifest either in a pattern catalogue or in a pattern language (Kotzé et al., 2012). A pattern catalogue is considered a list or a collection of pattern items. The relation of patterns is not necessarily present in a catalogue. A pattern language is a structured method of describing patterns. There are only a small number of pattern collections on EA development, including the EAM Pattern Catalogue (Ernst, 2008; Buckl et al., 2010b) and a pattern catalogue by Lankhorst and Oude Luttighuis (2009). The EAM Pattern Catalogue provides further details and guidance for systematically established EAM. The pattern catalogue described by Lankhorst and Oude Luttighuis is a multichannel management catalogue to help organisations in managing and aligning different information channels used in customer communication. Kotzé et al. (2012) proposed characteristics for pattern generation (*Table 11)*.

Table 11. Characteristics for Pattern Generation (Kotzé et al., 2012)

ID	CHARACTERISTICS
ch01	A pattern is grounded in a domain by being associated to a context as well as other patterns and has no meaning outside the design domain or the pattern language it forms part of
ch02	A pattern implies an artefact
ch03	A pattern bridges many levels of abstraction
ch04	A pattern is both functional and non-functional and should include the reason(s) and rationale why the solution is recommended, and what trade-offs are involved when such a pattern is used
ch05	A pattern is both a process and a thing, relating the design process and structure of the end product
ch06	A pattern is validated by use and cannot be verified or validated from a purely theoretical framework, without its practical application in its relevant context
ch07	A pattern captures a big idea and is meant to focus on key problems within a context and implies maximum reusability
ch08	A pattern conforms to a particular template
ch09	A pattern should be part of a pattern language where different patterns work together to solve a recurring complex problem in a particular context

TOGAF provides a minimum set of necessary EA models, called artefacts (TOG, 2015). There are both descriptive and composite artefacts in the recommended artefact list. These artefacts are attached to certain ADM phases. A shortened artefact list is given in *Table 12*. The table contains brief content and the corresponding ADM phase. The complete TOGAF artefact list contains 56 artefacts. The entire list with brief descriptions can be found in *Appendix C*.

Table 12. A Shortened Artefact List for Exemplary Purposes (based on TOG, 2015)

ARTEFACT	BRIEF CONTENT	TOGAF ADM PHASE
Business Service/Function Catalogue	A functional decomposition to identify capabilities of an organisation	Phase B
Goal/Objective/Service Diagram	A mapping to show how a service contributes to the achievement of a business strategy	Phase B
Data Entity/Business Function Matrix	A list that links data entities and business functions within an organisation	Phase C
Process/Application Realisation Diagram	A diagram to depict the sequence of events when multiple applications are involved in executing a business process	Phase C
Application/Technology Matrix	A mapping of applications to technology platform	Phase D

Enterprise architecture analysis types are methods that are capable of assessing EA models, e.g. evaluating dependencies, isolated objects, complexity or heterogeneity. A number of research efforts have focused on proposing models for EA analysis, i.e. EA-based analysis types that are capable of assessing EA models. Buschle et al. (2011) and Ullberg et al. (2010) introduced general process models for EA analysis. The process consists of three steps: 1) EA Assessment Scoping, 2) Evidence Collection and 3) EA Analysis. Buschle et al. (2011), Lankhorst (2013) and Niemann (2006) proposed potential EA analysis categorisations according to e.g. 1) quantitative/qualitative or 2) static/dynamic groupings. Lankhorst (2013) gives a categorisation of quantitative, portfolio and functional analyses. Quantitative analyses include e.g. performance analysis, quantitative modeling and quantitative analysis. Functional analyses cover static and dynamic EA analysis types. Niemann (2006) classifies EA analysis types as analysis potential for examining 1) dependencies, 2) coverage, 3) interfaces and 4) complexity. *Table 13* summarises a classification scheme for EA analysis approaches (Buckl et al., 2009a).

Table 13. Classification Scheme for EA Analysis Approaches (Buckl et al., 2009a)

BODY OF ANALYSIS	Structure	Behaviour statistics	Dynamic behaviour
TIME REFERENCE	Ex-post		Ex-ante
ANALYSIS TECHNIQUE	Expert-based	Rule-based	Indicator-based
ANALYSIS CONCERN	Functional		Non-functional
SELF-REFERENCIALITY	None	Single-level	Multi-level

Lantow et al. (2016) introduced an assessment framework based on the classification scheme of Buckl et al. (2009a). They assessed EA analysis approaches from recent literature against the classification scheme of Buckl et al. (2009a). In their assessment, they revealed that there was no instance for expert-based analyses. In addition, the minority of EA analyses worked on the basis of dynamic behavior or prescriptive manner.

Buckl et al. (2009a, 2009b), Niemann (2006) and Wagter et al. (2012) proposed EA analysis collections. According to the object being investigated (e.g. Dependency, Coverage, Interfaces, Heterogeneity, Complexity, and Conformity), different analysis procedures are introduced. EA analysis types will be introduced and assessed in a subsequent section. TOGAF also contains some details on EA analysis and EA assessment. EA analysis techniques provided by TOGAF include gap analysis, architecture compliance review, enterprise coherence assessment, business value assessment technique, architecture governance assessment, architecture maturity assessment. In addition, to assess the architecture landscape, TOGAF provides several resources to review: consolidated gaps, solutions, dependencies matrix, EA state evolution table, business interaction matrix, ISs interoperability matrix, business footprint diagram, governance log, responses to architecture compliance review, maturity models (TOG, 2015).

To summarise the analytical potential of EA evaluation methods, a comparative study will be introduced briefly. Hoffmann (2008) proposed an in-depth analysis of EA evaluation methods by using the evaluation criteria of 1) Business Architecture, 2) Information Architecture, 3) Technology Architecture and 4) Financial Assessment. In this study, EA evaluation methods are classified into these categories and strengths, and addressed evaluation needs are listed to each evaluation method. *Table 14* summarises the analysis of EA evaluation methods by Hoffmann (2008).

The catalogue for possible EA evaluation methods is largely applicable for research framework incorporation for several reasons. Firstly, the categorisation scheme of methods can be built into the proposed EA-based misalignment assessment framework. Secondly, some of the used techniques can also be applicable for misalignment symptom detection, e.g. conceptual modeling. On the other hand, some out-of-scope evaluation methods are also listed in this comparison from the perspective of applicability (e.g. financial methods and technology/infrastructure architecture evaluation). Tools for supporting the process of EA analysis are expounded by Buckl et al. (2011), Buschle et al. (2011), Bock et al. (2016), Simpson and Storer (2015) and Ramos et al. (2015). Rule generation and testing can also be used for EA analysis and EA assessment (for examples see e.g. Deiters et al., 2009).

Table 14. Analysis of EA Evaluation Methods (based on Hoffmann, 2008)

METHOD CATEGORY	EA EVALUATION METHOD	TECHNIQUES IN USE
Business Architecture	Governance Modelling	▪ Conceptual modeling and review
	Business Process Modelling	▪ Conceptual modeling and review
	Business Process Simulation	▪ Simulation
Information Architecture	Moody's Framework (Moody and Darke, 1998)	▪ Reviews and metrics
Technology/ Infrastructure Architecture	Benchmarking	▪ Performance, reliability, and cost measurement
Financial Methods for assessing the business value of IT investments	Business Value Index (BVI)	▪ Priority-based assessment of future investments
	Total Economic Impact (TEI)	▪ Risk-adjusted Return on Invest calculation
	ValIT	▪ Value governance, Portfolio management, and Investment management
	Applied Information Economics (AIE)	▪ IT investment assessment through mathematical and scientific methods

In conclusion, several works have addressed the problem of EA analysis. All these works explore the applicability of EA analysis for EA evaluation, however, they do not specialise EA analysis for (mis)alignment assessment. The proposed research aims to narrow this gap by introducing a framework for EA-based misalignment symptom detection. In this research the concept of architecture patterns will be applied, i.e. misalignment symptoms will be described according to the guidelines of pattern generation. This research item will be connected to TOGAF artefacts, which will serve as containing models for misalignment symptoms. The proposed research framework will utilise several EA analysis types, which will be described in detail in the following subsections. Finally, the research will use certain parts from the studies on EA analysis approaches.

2.8 EA Alignment Methods

There have been many attempts to investigate reciprocal contributions between strategic (mis)alignment assessment and EA analysis. Recently, there has been an increased interest in EA-based alignment assessment, especially in matching EA domains to evaluate the state of alignment in an organisation. The following subsection provides insight into the components of this concept. The state of alignment can be examined via several methods. One of the main research methods of analysing alignment is enterprise architecture-based assessment. This method assesses how IT is aligned with organisational goals. While earlier studies on alignment assessment primarily focused on strategic and holistic perspectives, the innate connection between business models and architectures have not been revealed (Chen et al., 2005). Enterprise architecture describes the logical structure of the different architecture layers and links all levels from business strategy to IT implementation. In this sense, EA enables us to assess the alignment between business and IT. Undertaking an architectural assessment is a helpful way to determine the state of alignment and to identify re-architecture needs. Architecture assessment consists of sole architecture layer analysis, as well as fit analysis between the different layers. After architecture assessment re-alignment (or re-architecture) techniques are used (Enagi and Ochoche, 2013). Architecture alignment methods combine different alignment analysis types, alignment assessment frameworks, and EA analysis techniques in order to propose EA-based tools for alignment assessment.

Many authors have linked enterprise architecture to strategic alignment. Pereira and Sousa (2004) identified that the operation of the different architecture components relates to alignment performance. Bounabat (2006) crashed the different EA layers in order to assess the state of alignment. Elhari and Bounabat (2010; 2011) set up an architecture-based maturity model for alignment assessment. Wegmann et al. (2005) proposed an EA framework that is able to check alignment along functional and organisational hierarchies. Dahalin et al. (2011) proposed a methodology to define how relevant EA is in addressing strategic alignment. Vasconcelos et al. (2007), as well as Sousa et al. (2005), determined measures to assess information system architecture.

The problem of enterprise architecture alignment has been extensively studied in literature. Aier and Winter (2009) focused on the integration of business and IT architecture domains. Their framework collects requirements for architecture alignment and proposes artefacts for alignment architecture. The Kalcas framework (Castellanos and Correal, 2012) dealt with the semi-automatic business process and data architecture alignment. It detects alignment patterns in the EA domains. It is an ontology matching-based model which supports the alignment of business architecture and data architecture via detecting potential alignments and misalignments between the architecture domains. The LEAP method (Clark et al., 2012) proposed an approach which supports architecture alignment. It includes a text-based language and a method to match as-is and to-be architecture stages as well as to simulate logical and physical EA models. Saat et al. (2010) introduced an EA metamodel for different business-IT alignment situations. SEAM framework (Wegmann et al., 2005, 2007) provided a description of an ideal alignment situation in which alignment exists between the business and IT domains. Decoupling mechanisms (Aier and Winter, 2009) focused on the integration of business and IT architectures. These instruments collect requirements for architecture alignment and propose artefacts for alignment architecture. In Saat et al. (2010) an EA metamodel was introduced for different business-IT alignment situations. The metamodel consists of enterprise entities, entity attributes, and entity relationships. Magoulas et al. (2012) proposed a framework and a comparative analysis for the usage of architectural approaches in attaining alignment. They investigated four alignment approaches (Zachman framework, TOGAF, GERAM, E2AF) in the context of aligning the constitutional parts of an EA. The analysis is made along the previously introduced alignment dimensions, viz. socio-cultural alignment, functional alignment, structural alignment, infological alignment and contextual alignment.

The above-introduced studies on architecture-based alignment assessment prove that it is a relatively young, evolving topic. Some issues on architecture alignment assessment are still open to debate. To give an example, the different views on 'which layers to align' will be introduced. Chen (2002) argues that 1) business models, 2) business architectures and 3) IT architectures have to be aligned with each other. Wieringa et al. (2003) stress the importance of application architecture and business architecture alignment. Pereira and Sousa (2004) argue that 1) business, 2) information, 3) application and 4) technical architecture alignment is necessary. It means that all mentioned layers have to be aligned with all other layers. Last but not least, Enagi and Ochoche (2013) point out that aligning 1) business and application, 2) application and information as well as 3) business and information layers are satisfactory.

Architecture-based alignment assessment, as introduced above is a useful way to analyse the state of alignment through enterprise architecture components. This method is also applicable to the concept of misalignment. To rephrase the definition of misalignment in the context of enterprise architecture, it can be stated that misalignment is an irregular condition that 1) destroys the different architecture components as well as the desired fit between them, 2) means the inaccurate mappings between the different architecture layers (Chen et al., 2005; Carvalho and Sousa, 2008).

There are a few studies on EA-based misalignment assessment in literature. They primarily deal with misalignment detection methods. The first study on architecture-based misalignment assessment was conducted by Pereira and Sousa (2004). They pointed out the relationship between architecture components and alignment performance, stating that alignment performance can be assessed by measuring misalignments between the architecture layers. They argued that misalignment can be deduced from three different perspectives: 1) from the improperness of business process and business information alignment, 2) from the improperness of business process and application alignment and 3) from the improperness of application and business information alignment. In addition, they identified that misalignment occurs when the state of alignment splits up between the above-mentioned layers. Finally, they introduced a set of questions which helps to detect misalignments between the different layers.

The BITAM approach (Chen et al., 2005) dealt with business and IT architecture misalignment management. It was an engineering-principled misalignment detection and correction method that connected misalignment with architecture. It set up 12 steps through which misalignment can be detected and corrected. The aim of the twelve steps was fourfold: 1) to capture the business goals and visions and to negotiate them between the stakeholders, 2) to document the different architectures, 3) to measure and assess misalignment and 4) to determine re-alignment strategies. In the BITAM project, a three-level model was defined, in which business model, business architecture and IT architecture were analysed, trying to define the signs of inappropriate mappings between the different layers. The goal of this method was to manage misalignment through fitting the different architecture layers, i.e. business architecture, IT architecture, application architecture and technical architecture. The approach stressed the effects of misalignment on architecture layers.

The BISMAM approach (Carvalho and Sousa, 2008) also connected misalignment to enterprise architecture. This model pointed out that enterprise architecture alignment is a prosperous way to implement misalignment detection, correction, and prevention. It was a symptom-based approach defining a set of preliminary signs that forecasts the danger of misalignment. The model stressed that misalignment identification can be best executed by symptom and sign analysis. It provided an initial misalignment cause library and collected misalignment detection techniques. The main idea of the BISMAM model was that misalignment symptoms can be connected to possible misalignment therapies and vice-versa. The model defined the nomenclature of misalignment, created the general denotation of misalignment and provided several examples of misalignment classification.

Elhari and Bounabat (2011) examined the different relations between the architecture layers. They proposed a platform that measured the difficulties in the IS elements. They stated that these difficulties harm the state of strategic alignment. They suggested different efforts to improve strategic alignment in an organisation.

EA alignment methods try to integrate alignment evaluation frameworks, misalignment assessment frameworks and EA analysis techniques to propose EA-based tools for (mis)alignment assessment. However, for the most part, existing approaches have no explicit potential for misalignment symptom detection. None of the proposed techniques can be directly applied to this problem. The contribution of this study extends results on approaching EA-based misalignment symptom detection. The framework proposed in the dissertation can be considered as a precursor step for integrating the concepts and potentials of EA analysis, (mis)alignment assessment and EA alignment. In the proposed framework typical misalignment symptoms will be connected to relevant EA artefacts and suitable EA analysis types along traditional alignment perspectives. This section introduced the theoretical background of the study. The dissertation continues with an introduction to research methodology.

In this section, a literature overview was given on research foundation and the topics of 1) strategic alignment, 2) misalignment and 3) enterprise architecture management. It was followed by a succinct introduction to EA-based alignment assessment techniques, with special attention to the recent literature on EA-based alignment and misalignment analysis. In the next section, the research methodology will be presented in detail.

3 RESEARCH METHODOLOGY

This section proposes an overview of the research methodology used in the Ph.D. dissertation. The Research Methodology part commences with the basics of research design. It is followed by some methodological choices, i.e. the decisions for inductive and qualitative research and a succinct introduction to research methodologies chosen for framework building (Design Science Research) and empirical validation (Case Study Research). The section contains a rehearsal of the research questions as well. Additionally, the research methodology section introduces a concept categorisation for EA-based misalignment assessment to provide alternative ways of approaching the research topic. Subsequently, to provide methods for answering research questions, the section presents the proposed research methodology. The Research Methodology section concludes with the description of the implementation. In this part of the section, details are given on how to develop queries for EA-based misalignment symptom detection. Finally, the Research Methodology section ends with the description of methods for data collection, data analysis, and result interpretation.

3.1 Research Design

The research methodology section contains the overall strategy to choose and integrate the constituent parts of the study. A momentous phase of composing the research methodology is research design. It constructs the blueprint of the research approach, i.e. the mixture of chosen research methods as well as data collection, measurement, and data analysis techniques. Research design ensures that the research strategy is built in a coherent and logical way. In addition, it supports the research approach to address the research problem and realise the specific research objectives (De Vaus, 2001; Creswell, 1994).

In constructing the research approach the interactive model of research design will be used (Maxwell, 1996). The structure of the proposed research model will reflect the recommendations of the model. All the justifications for the chosen research methods will be introduced in the subsequent parts of the section. *Figure 20* shows the structure of the interactive model.

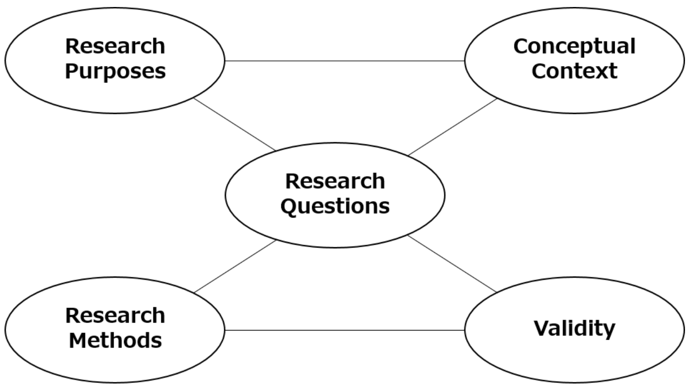


Figure 20. Interactive Model of Research Design (Maxwell, 1996)

3.2 Methodological Choices in Research

Choosing appropriate IS research methodologies is a key point in constructing the research approach (Galliers and Land, 1987). As an initial phase, a decision has to be made on the nature of the proposed research. In this subsection, the decision on an inductive or a deductive approach will be given. While the deductive approach deals with hypothetical testing of deduced assumptions, the inductive approach aims at exploring and describing new and theoretically unexplored research areas. Exploratory research goals build on the inductive logic, i.e. theories are developed according to the generalisation of analysed research data (Babbie, 1989). The research will be based on the *inductive approach* since my research has an exploratory manner: it aims to explore a less grounded research area and proposes new ways of analysing the subject.

The second influential choice on the research approach lies in the decision on quantitative or qualitative research. Quantitative research works with mathematical-statistical resources in the data analysis phase. It focuses on the statistical analysis of large amounts of data. By means of the qualitative research, we are able to explore and understand the research context. Qualitative research works with in-depth analysis techniques, however, by analysing only small amounts of data. (Patton, 1990; Myers, 1997; Denzin and Lincoln, 2008). From this point of view, this research uses the *qualitative approach*, since the main goal of the proposed research is to explore new theories by developing new approaches for (mis)alignment assessment.

The proposed research combines methods from both social sciences and information systems studies. In addition, the research uses a *mixed approach* for framework building and validation. Mixed methods research (Creswell and Clark, 2007; Creswell, 2014) is frequently used both in social sciences and in IS research. In this research the Design Science Research and the Case Study Research methodologies will be mixed: Framework building will be supported by the Design Science Research methodology, while empirical validation will be conducted by using the Case Study Research method. Case Study Research is ever more often combined with the DSR method both in general terms and in recent IS studies (for some examples see e.g. the studies of Nabukenya (2011) and Peffers et al. (2006)). Both the Design Science Research and the Case Study Research methodologies will be introduced briefly in the following subsections.

3.2.1 Design Science Research for Framework Building

In the proposed research the Design Science Research (DSR) methodology will be used to support framework building. It is a step-by-step research method for building research artefacts. Design Science Research is a frequently used research method in information systems studies (Hevner and Chatterjee, 2010; Hevner et al., 2004; March and Storey, 2008; Goes, 2014; Peffers et al., 2007; Sunkle et al., 2015). *Figure 21* introduces the general process of DSR. In the proposed research the DSR process will be used to define research artefacts.

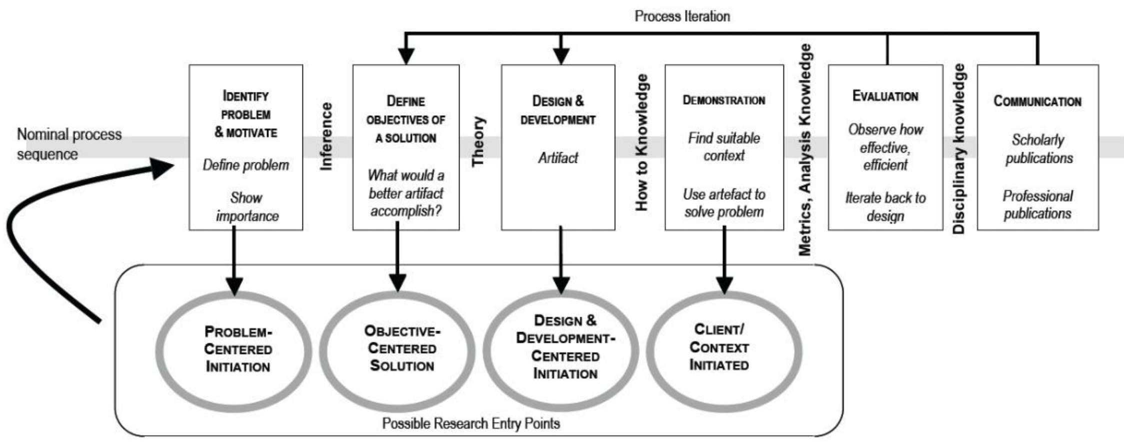


Figure 21. Design Science Research Methodology: Process Map (Peffers et al., 2007)

3.2.2 Case Study Approach for Empirical Validation

The proposed research will use the Case Study Research (CSR) method for empirical validation and testing. The case study method allows an in-depth analysis of a research problem. It helps to narrow the field of study by focusing on some typical empirical examples. In addition, it provides ways to test whether a proposed theory or model applies to real-world phenomena (Yin, 1994; Eisenhardt, 1989; Stake, 1995).

The use of the case study method is preferred when the concepts under investigation and their relations cannot be examined in an isolated manner. Case studies will be used to evaluate the correlation of practice and main theoretical concepts. There are several guidelines for building case studies (Darke et al., 1998; Woodside and Wilson, 2003; Atkins and Sampson, 2002) and for building case studies in the IS field (Shanks, 2002; Shanks and Parr, 2003; Cavaye, 1996; Smith, 1990; Dubé and Paré, 2003). The aim of using the case study method is threefold (Eisenhardt, 1989): 1) to illustrate or explain a theory, 2) to create an applicable theory, 3) to validate and test an existing theory. Yin (1994) lists the potential sources of research strategies as follows:

- Experiments, researcher observations
- Questionnaire surveys, interviews
- Secondary analyses, documentations
- Historical analyses, archival records
- Procession of a case study
- Physical artefacts

Case studies are usually based on combined data collection methods which can result in both qualitative and quantitative analyses. Features of case study research strategies lie in (Bensabat et al., 1989):

- investigating a phenomenon in its natural setting
- using multiple methods for data collection
- collecting observations from one or more entities
- its exploratory nature
- the potential of exploring complex situations
- the fact that no experimental control or manipulation is needed
- the fact that no dependent or independent variables are defined
- the fact that results depend on the researcher's ability to observe and perceive
- the possibility of changing data collection methods throughout the research
- the nature of the normal phenomenon of a routine procedure
- relating to a single or multiple events
- its idiographic nature

Advantages of using case studies as a research tool lie in 1) providing an overall picture of the research problem, 2) providing an in-depth understanding of the problem, 3) revealing hidden relationships and explanations, 4) providing wide-range flexibility, 5) enabling interaction between data collection and data analysis, 5) providing detailed illustrations (Babbie, 1989; Galliers, 1992).

Drawbacks of the case study approach can be listed as follows: 1) inaccurate description of large populations, 2) providing suggestions instead of conclusions, i.e. definitive conclusions cannot be deduced from the results, 3) the lack or weakness of reliability, 4) inadequacy to generalise findings, 5) the lack or weakness of setting and experiment reproduction, i.e. results cannot be reproduced by others, 6) the distortion of the model (Babbie, 1989).

Yin (2013) summarises the process of case study method as follows (*Figure 22*):

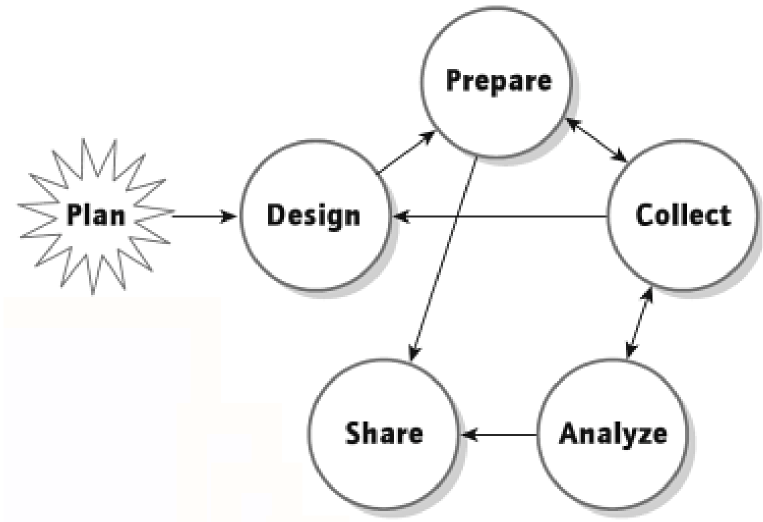


Figure 22. The Process of Case Study Method (Yin, 2013)

To avoid any threats of the case study approach, Babbie (1989) provides five criteria to be met: 1) Definition of a relatively neutral aim, 2) The use of known data sources, 3) Adequate time frame for examination, 4) The use of known data collection methods, 5) Consistency with state of the art knowledge on the topic.

For empirical validation, the Case Study Research method will be used in the research. After developing the research model with the DSR approach, the model will be empirically tested with the Case Study Research method.

3.3 Research Questions

As listed in the Introduction section, the research focuses on the following research questions:

RQ1:	WHICH MISALIGNMENT SYMPTOMS CAN BE DETECTED VIA ENTERPRISE ARCHITECTURE ASSESSMENT?
RQ2:	WHICH DIMENSIONS AND DOMAINS ARE NEEDED TO EXAMINE IN AN EA MODEL TO DETECT MISALIGNMENT SYMPTOMS?
RQ3:	HOW DO EA MODELS MANIFEST DIFFERENT MISALIGNMENT SYMPTOMS?
RQ4:	WITH WHICH METHODS CAN WE EXPLORE THE DIFFERENT MISALIGNMENT SYMPTOMS IN EA MODELS?

With the support of the Interactive Model of Research Design by Maxwell (1996) and the methodological choices presented previously, the following subsections aim to provide an appropriate research method for answering research questions.

3.4 Concept Categorisation for EA-based Misalignment Assessment

In this section, an overview is given on potential concepts for EA-based misalignment assessment. Related concepts and solutions include means of both theory and implementation. This section aims to exhibit the setting and background of EA-based misalignment assessment, i.e. all possible means of approaching misalignment assessment from an EA-based perspective. In the section, the more influential and realisable approaches are deeply emphasised, while less feasible concepts are mentioned as alternative ways and are less expounded. *Figure 23* presents the concepts under review in the following subsections.

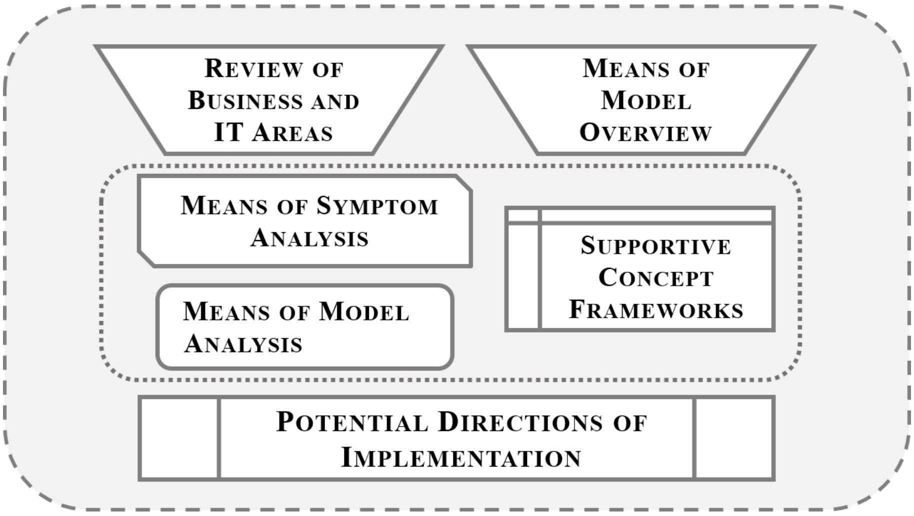


Figure 23. Areas of Concept Categorisation

3.4.1 Review of Business and IT Areas

Based on the SAM model, there are some influential areas in an organisation that have to be reviewed in order to get a comprehensive picture about business and IT operation and relationship. *Table 15* summarises the most important organisational areas that are needed to comprehend before proceeding to Business-IT assessments.

Table 15. The Most Important Business-IT Areas to Review

Area	Sub-Area	Organisational Model Concepts
Business	*Business Strategy*	▪ Business Strategy ▪ Business Goals, KPIs, Performance Measurement ▪ Customers, Market Segments ▪ Products and Services ▪ Value Chain
	Organisational Infrastructure and Processes	▪ Organisational Structure, Business Units and Functions, Business Roles ▪ Business Process Map and Process Models ▪ Project Portfolio
IT	*IT Strategy*	▪ IT Strategy ▪ IT Governance ▪ Standards, Best Practices ▪ Risk Management ▪ Value Transfer

(Continues)

Table 15. *(Continued)*

Area	Sub-Area	Organisational Model Concepts
		▪ Service Level Agreements and Architecture Contracts
	IT Infrastructure and Processes	▪ IT Process Map and Process Models ▪ IT Functions ▪ IT Organisational Structure, IT Roles, Process-, Service- and Application Owners ▪ Application Portfolio, Application Interfaces ▪ IT Service Portfolio and Service Catalogue ▪ Service Quality ▪ Capacity Management ▪ Configuration Management Database, Infrastructure Repository

	Enterprise Architecture	▪ EA models
		    ▪ Business Architecture
		    ▪ Data Architecture, incl. Data Entities, Physical and Logical Data Components
		    ▪ Application Architecture, incl. Application Interfaces, Physical and Logical Application Components
		    ▪ Technology Architecture, incl. Physical and Logical Technology Components and Technology Standards
		▪ Architecture Repository
		▪ Views and Viewpoints
		▪ Artefacts
		▪ Architecture Maturity and EA Model Confidence

Business-IT Relationship		▪ Demand Management ▪ Business/IT Ideas, Propositions, Innovation ▪ Requirements ▪ Complaint Handling ▪ Service Level Management ▪ Business-IT Organisational Maturity ▪ Investment Planning ▪ Business and IT Strategy Linkage, Business-IT Alignment

EA-based misalignment assessment needs to take all the above introduced organisational areas into consideration. However, the expansivity of these areas makes it difficult to compile a comprehensive assessment framework.

3.4.2 Means of Symptom Analysis

Matching the different domains of the SAM results in different types of misalignment symptoms in the underlying EA models (Coleman and Papp, 2006; Henderson and Venkatraman, 1993; Saat et al., 2010). Misalignment symptoms found in related works (Carvalho and Sousa, 2008; Pereira and Sousa, 2005; Sousa et al., 2005) will be used during the EA-based misalignment assessment. Misalignment symptoms from the related literature are composed into a symptom catalogue. This catalogue consists of specific misalignment symptoms, which were observed in organisations and published in previous literature on misalignment.

After collecting misalignment symptoms, descriptive and classification approaches can be used. Firstly, symptom description techniques are presented. Misalignment symptoms can be described from different perspectives: 1) as patterns of malfunctions, 2) by using description logic (DL), 3) with rules. In the first approach, the concept of design patterns (Gamma et al., 1995) is utilised. By using description logic, misalignment symptoms are described as DL statements (McGuinness and Wright, 1998). In the last approach, rule generation techniques are used for symptom description (de Moura Araujo et al., 2010; Cohen et al., 2015). Secondly, means of misalignment classification are given. Misalignment symptoms can be classified in different ways: 1) Symptoms can be collected according to SAM perspectives. Preliminary results are available on perspective-based symptoms (see *Appendix G*). 2) Another way of classification includes the localisation-based method. In this approach, symptoms can be located in a descriptive model of an organisation, e.g. the TOGAF metamodel (TOG, 2015) (for preliminary results see *Appendix F*). Further classification directions include: 3) symptoms collected to different misfit categorisations (Strong and Volkoff, 2010) and 4) entity-based symptom categorisation. In the latter, symptoms are collected to missing entity contents, missing entity liaisons and multiple entity relations.

There are several methods for revealing symptoms in underlying EA models. TOGAF serves the gap analysis technique, in which as-is and to-be architecture states are aligned for listing differences in the states (TOG, 2015). Additionally, Frantz et al. (2011) proposed a method for error detection in enterprise application integration solutions, which is also applicable for misalignment symptom detection. Another work on detection was proposed by Khellady et al. (2015), in which a methodology was introduced to reveal complex changes during metamodel execution. Subsequently, Heiser et al. (2015) presented a method for revealing hidden structures in organisational transformation. Furthermore, symptoms can also be revealed with 1) EA analysis types that are able to detect the symptoms in question, 2) containing EA artefacts that encompass the symptom and 3) EA analysis types that are able to detect certain classes of misfit types. In the proposed framework the last three approaches will be used.

In literature, different misalignment assessment techniques have been put forward to succeed in dealing with alignment evaluation from misalignment perspective. Most of them are symptom-based (e.g. Carvalho and Sousa, 2008; Sousa et al., 2005), while other works such as by Pereira and Sousa (2005) focused on proposing a process for misalignment assessment. Several approaches have been developed, but they provide minor support for EA-based implementation.

3.4.3 Overview of Organisational Models

Besides symptom analysis, misalignment assessment also includes an overview of organisational models. This process can be approached in two influential ways. On the one hand, architecture domains can be reviewed using, e.g. the architecture landscape technique or other architecture overview methods. On the other hand, SAM alignment domains can be reviewed on an EA basis.

The approach of architecture domain overview includes 1) perspectives of the architecture landscapes (e.g. views, viewpoints and different reference models, TOGAF artefact-based overview, artefact chains, in-layer and between-layer artefact groups, architecture domain building blocks), 2) different architecture overview methods (e.g. portfolio analysis, domain analysis, change impact analysis, landscape management, blueprint management) (Lankhorst, 2013; Ahlemann et al., 2012; Sunkle et al., 2013; Van der Linden et al., 2011; Simon and Fischbach, 2013) and 3) supportive concepts for architecture overview (e.g. EA model entity relationships, EA measurement items, architecture principles or architecture patterns) (Lankhorst, 2013; Aier et al., 2012; Hoogervorst, 2009).

A feasible approach for an EA-based alignment domain overview is to connect the SAM domains (Henderson and Venkatraman, 1993) with TOGAF artefacts (TOG, 2015). In this approach, TOGAF artefacts are attached to corresponding SAM domains, alignment types and alignment perspectives. In the proposed framework this kind of EA-based alignment domain overview will be used. Preliminary results on matching TOGAF artefacts with SAM domains are available in *Appendix G*. This approach also supports a dynamic view of the SAM model, i.e. tracking changes in the underlying EA models and artefacts over time. The Strategic Alignment Process (SAP) serves as a practicable method for tracking EA model changes. Further work should be undertaken on this subject.

3.4.4 Means of Model Analysis

After collecting and classifying misalignment symptoms, analytical operations can be performed on the EA models. Means of EA model analysis includes 1) alignment domain matching techniques, 2) architecture domain matching techniques and 3) the use of EA analysis types.

Firstly, alignment domain matching can be approached via, e.g. the ArchiMate language (Lankhorst, 2013), the I* technique (Gordijn and Akkermans, 2003), goal modelling techniques (Doumi et al., 2011a; Cohen et al., 2015) and the business value assessment technique of TOGAF (TOG, 2015).

Secondly, architecture domain matching techniques include, e.g. landscape mapping analysis (Sunkle et al., 2013), decoupling mechanism (Aier and Winter, 2009), ontology matching techniques (vom Brocke et al., 2014; Castellanos and Correal, 2012; Sandkuhl et al., 2015) and different techniques for integrating architecture domains (see e.g. Lankhorst, 2013).

Finally, EA analysis types provide feasible techniques for model analysis. There are different types of EA analyses, e.g. dependency analysis, network analysis, coverage analysis, interface analysis, complexity analysis, heterogeneity analysis, enterprise interoperability assessment, enterprise coherence assessment, inconsistency checking (Buckl et al., 2009a, 2009b; Hadar and Zamansky, 2015; Niemann, 2006; Wagter et al., 2012). Frameworks for EA analysis include some TOGAF-based techniques, e.g. architecture compliance review, architecture governance assessment, architecture maturity assessment or performance analysis (TOG, 2015; Lankhorst, 2013). Sources for EA analysis may also include some TOGAF-based approaches, e.g. consolidated gaps, solutions and dependencies matrix, EA state evolution table, business interaction matrix, information systems interoperability matrix, business footprint diagram, governance log, architecture compliance review log and maturity assessment log (TOG, 2015).

While all the above-introduced model analysis techniques can be applicable for misalignment assessment, in the proposed research framework model analysis will be performed with EA analysis methods. Further details on EA analysis are given in the literature review section as well as in the subsequent parts of the section.

Besides model analysis types that assist the analytical process, there are several influential concept frameworks in the field of EA-based alignment assessment that may support the establishment of the research methodology. 1) The Building Blocks for Enterprise Architecture Management Solutions (BEAMS) approach is built on the interplay of design and theory building by constructing a method to EA-based research solutions (Buckl et al., 2010a). 2) Meta-methodology concept (Noran, 2009) is considered a method to build different EA-based research methods. It provides a systematic method to set up research frameworks. It aims to combine concepts, related research models, and empirical data collections in order to define the research model. The concept builds on transformation logic, i.e. to produce new knowledge from input knowledge by means of operating the constructed research framework. The model is controlled by best practices, environment factors, and project scope, while EA frameworks and tools provide supportive resources. 3) The LEAP method (Clark et al., 2012) proposes an approach which supports architecture alignment. It includes a text-based language and a method to match as-is and to-be architecture stages as well as to simulate logical and physical EA models. 4) The SEAM framework (Wegmann et al., 2007) provides a description of an ideal alignment situation in which alignment exists between the business and IT domains.

These supportive methods can be used in constructing the research framework. In addition, the DSR process can be extended with two of the above introduced, supportive methodologies. Besides the general DSR process, the BEAMS approach can support artefact design and the Meta-methodology concept can support the connection of research concepts, related models and empirical data collections (misalignment symptom catalogues, artefact catalogues, EA analysis catalogues) in the research framework.

3.4.5 Directions for Implementation

After reviewing the areas of symptom analysis, model overview and model analysis, potential directions are given for implementing EA-based misalignment assessment and symptom analysis. *Table 16* summarises potential directions for implementation. Each approach is briefly explained and attached with the relevant literature reference of the field.

Table 16. Summary of Potential Implementation Directions

Approach	Description	Literature Reference
Graph-based approach for dependency analysis	In this approach dependency analysis is performed on the XML-format EA models. Dependency analysis reveals dependencies between EA model entities. Graph-based visualization can be used to show the results of the dependency analysis. Rules can be identified and interpreted in the graph-based visualization.	Lee, 2013; Gona and Smith, 2011
Rule construction and testing – a pattern-based approach with DL statements	Misalignment patterns described as DL statements will be transformed into formal rules. Rule construction can be supported by the Semantics of Business Vocabulary and Rules (SBVR) standard. SBVR helps to formalise misalignment patterns as rules. Rule description can be performed by using the Object Constraint Language (OCL). Since OCL is a declarative language for describing rules, it is able to describe rules which were constructed according to the SBVR standard.	Mishra and Sureka, 2015; Moschoyiannis et al., 2010; Bajwa and Lee, 2011; Cohen et al., 2015; Baier et al., 2015
XML-based analysis tools	In this approach, formal rules are tested with XML analysis tools. It means that the above described formal rules of misalignment symptoms can be identified in the artefact chains by using different XML analysis tools. The approaches of XML matching, XML schema matching, and XML parsing serve as rule testing	de Boer et al., 2005

(Continues)

Table 16. *(Continued)*

APPROACH	DESCRIPTION	LITERATURE REFERENCE
	instruments. XML parsing allows us to split up information in the XML document into its constituent parts. XML schema is a description of an XML document, therefore XML schema matching enables us to check constraints on the structure and the content of an XML document. Finally, the Scala language supports the creation of queries for XML matching.	
EA analysis in standalone implementation	In this aspect of implementation, EA analysis is performed in a standalone implementation. There are available implementations for e.g. dependency analysis, heterogeneity analysis and network analysis. These analyses are able to reveal redundancies and the existence or lack of model entity relationships in both within-layer and between-layer EA models.	Dietrich et al., 2008; Franke et al., 2009; Buckl et al., 2009b; Johnson et al., 2007
Graph-based approach for additional analyses	In this approach, the concepts of hypergraphs and graph databases are used. Logical languages, such as the Prolog serve as a query language above the constructed hypergraphs from EA models. Object-oriented processing techniques, pattern matching techniques, graph transformation, Petri nets and queries with semantic web languages, such as JENA are also available in this perspective of implementation.	Deiters et al., 2009; Buckl et al., 2008; Binz et al., 2012; Holschke et al., 2008; Raderius et al., 2008
Ontology-based EA layer matching techniques	This approach supplies the analytical capacity of ontology matching. Ontology is built from the EA model structure and ontology queries are executed in order to reveal misalignment symptoms.	Sunkle et al., 2013; vom Brocke et al., 2014; Castellanos and Correal, 2013; de Sainte Marie et al., 2011; van der Werf et al., 2012

As we can see from the above-introduced implementation direction collection, there are several ways for approaching EA-based misalignment assessment at the implementation level. In the proposed research framework the rule-based and the XML-based analysis toolkits will be utilised for symptom analysis. These directions will be combined, i.e. formal rules will be tested via XML-based tools.

To summarise concept categorisation, *Figure 24* and *Figure 25* contain and synthesise areas that are needed for EA-based misalignment assessment. These constructs summarise and integrate related concepts and establish a model for A) SAM-based (mis)alignment matching (*Figure 24*) and B) TOGAF-based misalignment analysis (*Figure 25*). *Figure 24* and *Figure 25* present a schematic view for concept summary, while *Appendix D* and *Appendix E* contain the whole concept categorisation schemes.

Figure 24 can be interpreted as follows: In this categorisation SAM domains (indicated as blue rectangles) are matched. SAM domains are described with different domain conceptualisations. SAM domain matches are supplied with techniques for domain-to-domain assignments. Matching on the infrastructure level results in analytical inputs for symptom detection. After symptom detection techniques, potential means of symptom categorisation are given. The operation is assisted with two types of supportive frameworks.

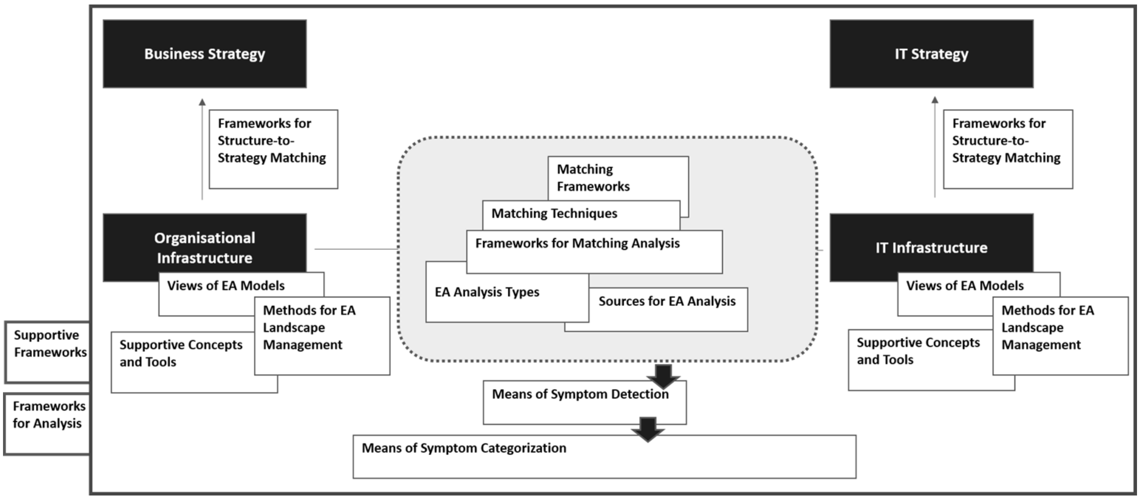


Figure 24. Categorisation of Concepts for EA-based Misalignment Assessment

Figure 25 can be interpreted as follows: The four concepts on the top may influence the Architecture Definition Document (ADD), while information sources of ADD are incorporated into the architecture definition document. In this concept architecture repository consists of 1) EA analysis techniques, 2) the ADD and 3) views of the architecture landscape. Sources of EA analysis are incorporated into EA analysis techniques. *Appendix E* contains the complete list of concepts for TOGAF-based misalignment analysis.

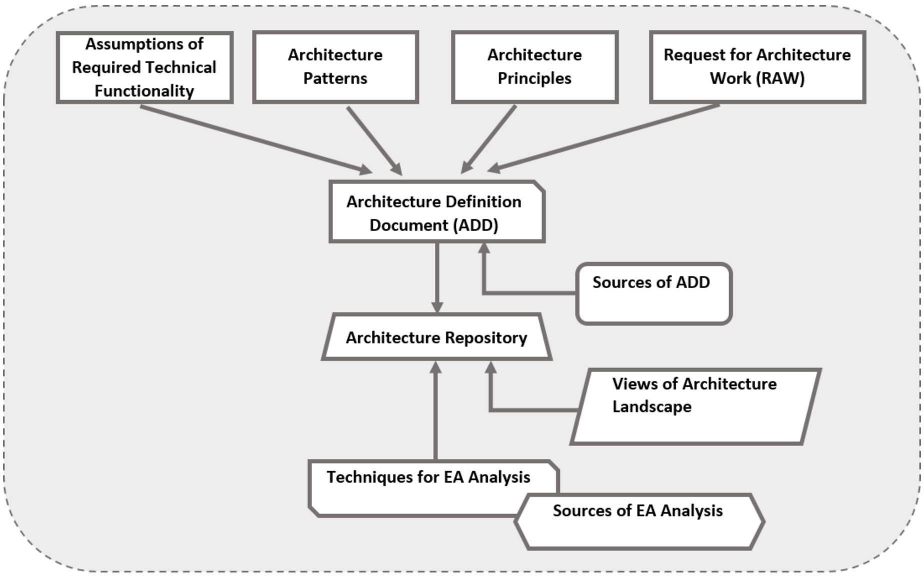


Figure 25. Concept Categorisation for TOGAF-based Misalignment Analysis

Finally, to ease traceability, concept categorisation areas are connected to corresponding research questions, viz.:

RQ1: WHICH MISALIGNMENT SYMPTOMS CAN BE DETECTED VIA ENTERPRISE ARCHITECTURE ASSESSMENT?

CORRESPONDING CONCEPTS:
3.4.2 Means of Symptom Analysis

RQ2: WHICH DIMENSIONS AND DOMAINS ARE NEEDED TO EXAMINE IN AN EA MODEL TO DETECT MISALIGNMENT SYMPTOMS?

CORRESPONDING CONCEPTS:

3.4.1 Review of Business and IT Areas
3.4.3 Overview of Organisational Models

RQ3: HOW DO EA MODELS MANIFEST DIFFERENT MISALIGNMENT SYMPTOMS?

CORRESPONDING CONCEPTS:

3.4.3 Overview of Organisational Models
3.4.5 Directions for Implementation

RQ4: WITH WHICH METHODS CAN WE EXPLORE THE DIFFERENT MISALIGNMENT SYMPTOMS IN EA MODELS?

CORRESPONDING CONCEPTS:

3.4.2 Means of Symptom Analysis
3.4.4 Means of Model Analysis
3.4.5 Directions for Implementation

3.5 Proposed Solution

This subsection introduces the proposed solution. In this part, an analytical solution will be built to approach the topic of strategic alignment from an EA-based perspective. The problem of business-IT alignment will be translated into the aspects and analytical potential of enterprise architecture. The section has two main parts. First, the conceptual design will be given about the research framework. This part will be followed by the introduction of the proposed research methodology. Both parts reflect the research questions and maintain the coherence of research design. Proposed framework and proposed research methodology stem from previously introduced research methodology choices and concept categorisation aspects. Research steps ensure the achievement of research objectives presented in the Introduction section. The achievement of the research objectives is guaranteed by the use of the interactive research model introduced in the Research Methodology section.

3.5.1 Conceptual Design

After categorising research concepts, the main steps of the proposed research will be introduced. The section lists the sequence and the brief content of each research phase. The subsection presents an approach for EA-based misalignment assessment, i.e. a solution for assessing the misalignment phenomenon in EA models. The research takes a rule-based approach to reveal the symptoms of malfunctioning alignment areas. The research steps are aggregated into three layers: 1) Misalignment Layer, 2) Enterprise Architecture Model Layer and 3) Analysis Layer. The layers refer to the research questions and the previously introduced research question – concept categorisation matches. In this sense:

- *Misalignment Layer* refers to
  - *RQ1* and *RQ2*,
- *EA Model Layer* refers to
  - *RQ3*,
- *Analysis Layer* refers to
  - *RQ4*.

In the following subsections, every research step will be explained briefly.

3.5.1.1 Misalignment Layer

The research stems from the concept of alignment assessment. Nevertheless, it takes an inverse perspective, i.e. alignment assessment is performed from the aspect of misalignment. The state of misalignment is approached from its symptoms. Misalignment symptom analysis is executed in order to assess the state of alignment.

This phase is concerned with the construction and formal description of misalignment symptoms. Misalignment symptom construction is based on the matching of the SAM alignment domains. A formal description of misalignment symptoms includes pattern generation. *Table 17* contains the steps of the first research phase.

Table 17. Research Steps in Misalignment Layer

Research Step	Description
Alignment Domain Matching	Matching of alignment domains in the SAM model enables us to construct misalignment symptoms. These symptoms describe typical mismatches between the domains of the Strategic Alignment Model.
Misalignment Symptom Classification	Misalignment symptoms identified in the previous step will be classified by traditional alignment perspectives. The classification helps to manage misalignment symptoms in a structured manner.
Misalignment Pattern Generation	Misalignment symptoms will be converted into misalignment patterns. To do so, the analogy of design patterns will be used. Misalignment symptoms will be identified as alignment anti-patterns that encumber the achievement of alignment. The pattern-based approach helps the foundation of symptom-based identification in the underlying EA models.

3.5.1.2 Enterprise Architecture Model Layer

The concept of enterprise architecture management will be used as an analytic tool for misalignment assessment. Symptoms of misfits will be investigated in the underlying EA models. Thus, the second research phase aims at preparing the underlying enterprise architecture models for the misalignment symptom detection. The phase consists of model transformation, artefact decomposition, and export file generation. *Table 18* contains the steps of the second research phase.

Table 18. Research Steps in EA Model Layer

RESEARCH STEP	DESCRIPTION
Organisational Model Transformation	Organisational model transformation deals with the conversion of different model sources (process maps, process models, organisational charts, landscape maps, balanced scorecards, value chain diagrams, etc.) into enterprise architecture models. The transformation will be executed on the basis of the TOGAF approach.
Artefact Definition	Transformed enterprise architecture models allow us to define analysable architecture artefacts. EA models will be decomposed into architecture artefacts. The artefacts will be selected according to the ability of the artefact to identify the symptoms of misalignment. After determining necessary architecture artefacts, artefact chains will be developed. Artefact chains will serve as connectors between architecture domains since artefact chains are able to cover the necessary matches between the business, data, application and technology architecture domains.
Model Export	To prepare the EA models for symptom detection, EA models and architecture artefacts will be exported to XML format.

3.5.1.3 Analysis Layer

The third phase is concerned with the implementation details of the proposed research. In the analysis layer, a certain kind of enterprise architecture analysis will be performed. EA-based misalignment symptom detection will be conducted by means of formal rule testing, i.e. the analytical potential of rule generation and rule testing will be exploited. Misalignment symptoms will be defined as formal rules. After rule construction, rule testing approaches will be introduced. *Table 19* contains the steps of the third research phase.

Table 19. Research Steps in Analysis Layer

RESEARCH STEP	DESCRIPTION
Rule Construction	Misalignment patterns will be transformed into formal rules. Rule construction will use an XML-based technique, i.e. rule construction will be supported by Schematron, a pattern-based XML validation language.
Rule Testing	Rules will be tested with XML validation tools. Formal rules will be detected in the artefact chains by using XML analysis tools. Schematron-based queries enable us to check constraints on the structure and content of an XML document. XPath enables us to reach particular nodes in XML-based EA models. Rules described in Schematron language will be tested on the XML-based EA models.
Output Generation	Schematron-based testing results can be processed with different visualization tools. Firstly, Schematron Report Language can be used to create a report about testing results. Secondly, graph-based visualization tools and XML schema viewers can be used to visualise testing results. Finally, XSL Transformation can also be performed to create an output on testing results.

3.5.2 Proposed Research Methodology

This section provides an overview of the components and the construction of the proposed research methodology. The framework described in the subsequent parts of this section is a well-structured, easy-to-use tool to support misalignment symptom detection. The proposed research methodology builds on the above introduced conceptual design and uses a three-layer approach. The framework has four main parts, which are connected to the corresponding conceptual design layers:

1) *Alignment perspectives* are used to structure the approach of misalignment symptom detection. Alignment perspectives are decomposed into constituent SAM domain matches.
   - This part of the framework refers to *1) Misalignment Layer*.
2) A *misalignment symptom catalogue* is composed from symptom collections found in the recent literature on misalignment.
   - This part of the framework also refers to *1) Misalignment Layer*.
3) An *artefact catalogue* is introduced, which summarises potential containing EA models.
   - This part of the framework refers to *2) EA Model Layer*.
4) *EA analysis catalogue* describes potential EA analysis types that are suitable for revealing misalignment symptoms in containing EA models.
   - This part of the framework refers to *3) Analysis Layer*.

The proposed research methodology uses an alignment perspective-driven approach. In the first step, traditional alignment perspectives are provided with typical misalignment symptoms. In the second step, relevant artefacts are connected to the misalignment symptoms, which may contain the symptom in question. In the third step, suitable EA analysis types are recommended to the misalignment symptoms. These EA analysis types are able to detect the symptoms in the recommended containing artefacts. *Figure 26* introduces the constituent parts and the structure of the proposed framework. In the next subsections, the construction of the research methodology will be described. The operation of the methodology will also be introduced in this section.

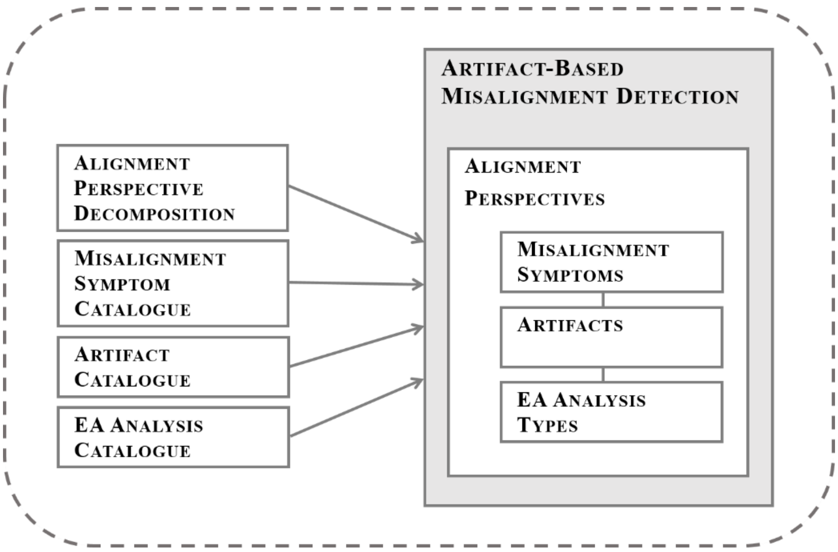


Figure 26. The Construction of Artefact-Based Misalignment Detection Framework

The first step of building the proposed research methodology is the matching of EA domains and alignment domains. In this phase, enterprise architecture domains are interpreted into alignment domains in order to be able to match alignment domains in an architectural style. It means that the domains of the SAM model (Business Strategy, IT Strategy, Business Structure and IT Structure) are matched with the underlying EA domains (Business Architecture, Data Architecture, Application Architecture, and Technology Architecture). *Figure 27* shows the process of matching alignment domains and enterprise architecture domains.

Figure 27. Matching of Alignment Domains and Enterprise Architecture Domains (based on Henderson and Venkatraman, 1993; TOG, 2015)

Traditional alignment perspectives are used to structure the approach of misalignment symptom detection. Alignment perspectives are decomposed into the corresponding SAM domain matches. *Table 20* introduces the constituent parts (the necessary SAM domain matches) of each traditional alignment perspective. To ease further reference, alignment perspectives and perspective components are coded.

Table 20. Decomposition of Alignment Perspectives (based on Henderson and Venkatraman, 1993)

ALIGNMENT PERSPECTIVE / PERSPECTIVE COMPONENT	*P.01 Strategy Execution*	*P.02 Technology Transformation*	*P.03 Competitive Potential*	*P.04 Service Level*
C.01 Matching of Business Strategy and Business Structure domains	●		●	
C.02 Matching of Business Structure and IT Structure domains	●			●
C.03 Matching of Business Strategy and IT Strategy domains		●	●	
C.04 Matching of IT Strategy and IT Structure domains		●		●

Alignment domain matches may contain the signs of misalignment. In this approach, the state of misalignment will be detected by its symptoms. This framework uses specific symptoms to be detected along alignment perspectives. The misalignment symptom catalogue (*Table 21*) is a collection of smaller symptom lists found in the recent literature on misalignment (Carvalho and Sousa, 2008; Pereira and Sousa, 2005; Sousa et al., 2005; Luftman, 2000; Luftman, 2003). The table shows those misalignment symptoms that 1) can be managed by EA-based techniques, 2) will be used in the proposed research methodology. To ease further reference, misalignment symptoms are coded.

Table 21. Misalignment Symptom Catalogue (based on Carvalho and Sousa, 2008; Pereira and Sousa, 2005; Sousa et al., 2005; Luftman, 2000; Luftman, 2003)

CODE	MISALIGNMENT SYMPTOM	LITERATURE REFERENCE
S.01	Undefined organisational mission, strategy, and goals	Carvalho and Sousa, 2008
S.02	Undefined business process goals, business process owners	Carvalho and Sousa, 2008
S.03	Lack of relation between process goals and organisational goals	Carvalho and Sousa, 2008
S.04	Undefined business roles or responsibilities	Carvalho and Sousa, 2008
S.05	Undefined or multiple hierarchy or lines of reporting	Carvalho and Sousa, 2008
S.06	Application functionality does not support at least one business process activity	Pereira and Sousa, 2005
S.07	Business process task supported by more than one application	Pereira and Sousa, 2005
S.08	Critical business process does not depend on scalable and available applications	Pereira and Sousa, 2005
S.09	Inappropriate application functionality	Sousa et al., 2005
S.10	Insufficient IT resources	Carvalho and Sousa, 2008
S.11	Lack of IT skills and competencies	Carvalho and Sousa, 2008
S.12	Lack of skills to develop or innovate certain types of products	Carvalho and Sousa, 2008
S.13	Poor IT planning and portfolio management	Carvalho and Sousa, 2008
S.14	Under capacity infrastructure	Carvalho and Sousa, 2008
S.15	Lack or poor systems performance monitoring	Carvalho and Sousa, 2008
S.16	Out of date technological infrastructure	Carvalho and Sousa, 2008
S.17	Technological heterogeneity	Carvalho and Sousa, 2008
S.18	Incompatible platforms or technologies	Carvalho and Sousa, 2008
S.19	Frequent periods when applications are unavailable	Carvalho and Sousa, 2008
S.20	Information consistency or integrity problems	Carvalho and Sousa, 2008
S.21	Undefined business service levels	Carvalho and Sousa, 2008
S.22	Only technical IT metrics in competency/value measurements, that are not related to business	Luftman, 2000
S.23	Ad-hoc business metrics in competency/value measurements, that are not related to IT	Luftman, 2000
S.24	Sporadically existing or Technical Service Level Agreements	Luftman, 2000
S.25	The scope of IT is traditional (e.g. accounting, email)	Luftman, 2000
S.26	None or ad-hoc standards articulation	Luftman, 2000
S.27	No formal architectural integration at the functional organisation level	Luftman, 2000
S.28	No formal architectural integration at enterprise level	Luftman, 2000
S.29	No formal architectural integration at inter-enterprise level	Luftman, 2000
S.30	Lack of or limited architectural transparency, flexibility	Luftman, 2000
S.31	Insufficient business users training	Carvalho and Sousa, 2008
S.32	Lack of data ownership	Carvalho and Sousa, 2008
S.33	Lack of data quality controls	Carvalho and Sousa, 2008
S.34	Undefined business information requirements	Carvalho and Sousa, 2008
S.35	Multiple applications managing the same information	Carvalho and Sousa, 2008
S.36	Unavailable requirements at the application level	Carvalho and Sousa, 2008
S.37	Wrong requirements implemented at the application level	Carvalho and Sousa, 2008
S.38	Users managed differently in different applications	Carvalho and Sousa, 2008

(Continues)

Table 21. *(Continued)*

Code	Misalignment Symptom	Literature Reference
S.39	Lack of application interfaces	Carvalho and Sousa, 2008
S.40	Undefined security requirements over the information entities	Carvalho and Sousa, 2008
S.41	Undefined capacity and performance requirements	Carvalho and Sousa, 2008
S.42	Insufficient involvement of business users in systems developments	Carvalho and Sousa, 2008
S.43	Undefined criteria to prioritise IT projects	Carvalho and Sousa, 2008
S.44	Lack of translation from business service levels to IT service levels	Carvalho and Sousa, 2008
S.45	Projects not used, canceled, late	Luftman, 2003
S.46	Systems integration difficulties	Luftman, 2003
S.47	Inappropriate resources	Luftman, 2003
S.48	Frequent IT reorganisations	Luftman, 2003
S.49	Ill-performing, unstable technology	Luftman, 2003
S.50	Frequent escalation of daily operating issues to executive level	Luftman, 2003
S.51	Not all processes create, update and/or delete at least one entity	Pereira and Sousa, 2005
S.52	Not all data entity attributes are read at least by one process	Pereira and Sousa, 2005
S.53	Not all processes assume the same entity description, i.e. there is not a single interpretation of the entity	Pereira and Sousa, 2005
S.54	Each business process should be supported by at least one application system	Pereira and Sousa, 2005
S.55	An entity is managed by only one application	Pereira and Sousa, 2005
S.56	If an information entity's ID is recovered, then the corresponding information entity should be created and deleted by the same computational process	Pereira and Sousa, 2005
S.57	The data management should be automatic among the application systems	Pereira and Sousa, 2005
S.58	Private entities should depend on restricted access applications	Pereira and Sousa, 2005
S.59	Confidential entities should depend on restricted access applications	Pereira and Sousa, 2005
S.60	The rate of updates should be correlated with rate of reads	Pereira and Sousa, 2005
S.61	Inserting the same data multiple times in different applications	Sousa et al., 2005
S.62	Logging in multiple times, once for each application they need to access	Sousa et al., 2005
S.63	Recovering from a failed operation across multiple systems, requiring careful human analyses to roll back to a coherent state	Sousa et al., 2005
S.64	Overcoming inappropriate application functionality	Sousa et al., 2005
S.65	Incoherent replicas of the same data, because they are updated by multiple applications	Sousa et al., 2005
S.66	Lack of or incomplete coherency from multiple transactions, because a single business process crosses multiple applications	Sousa et al., 2005

(Continues)

Table 21. *(Continued)*

CODE	MISALIGNMENT SYMPTOM	LITERATURE REFERENCE
S.67	Difficulties in gathering information from multiple systems and coding rules to produce a coherent view of the organisation's business information	Sousa et al., 2005
S.68	Different data structures when data migrates between applications	Sousa et al., 2005
S.69	Computational independence between applications	Sousa et al., 2005
S.70	Use of a point-to-point Application integration, rather than a "data store"	Sousa et al., 2005
S.71	Lack or minority of changes in business (organisation, processes, goals) induced by IT (over time)	Scott Morton, 1991

The next component of the proposed framework is the collection of possible EA artefacts. TOGAF-based artefacts are able to contain certain misalignment symptoms. In *Table 22* possible artefacts are introduced that will be used in the proposed research methodology. The content of the artefact catalogue derives from the TOGAF standard (TOG, 2015). It is an excerpt from the whole TOGAF artefact list. To ease further reference, artefacts are coded.

Table 22. Artefact Catalogue (based on TOG, 2015)

CODE	ARTEFACT	BRIEF CONTENT	TOGAF ADM PHASE
AF.01	Driver/Goal/Objective Catalogue	A breakdown of drivers, goals, and objectives to provide a cross-organisational reference of driver fulfillment	Phase B
AF.02	Role Catalogue	A list of all authorisation levels of an organisation	Phase B
AF.03	Business Service/Function Catalogue	A functional decomposition to identify capabilities of an organisation	Phase B
AF.04	Contract/Measure Catalogue	The master list of all agreed service contracts (and contract measures) within an organisation	Phase B
AF.05	Actor/Role Matrix	A matrix to show which actors perform which roles	Phase B
AF.06	Business Footprint Diagram	A mapping of business goals, organisational units, business functions, business services, and delivering technical components	Phase B
AF.07	Functional Decomposition Diagram	A list of relevant capabilities within an organisation	Phase B
AF.08	Goal/Objective/Service Diagram	A mapping to show how a service contributes to the achievement of a business strategy	Phase B
AF.09	Business Use-Case Diagram	A diagram to show the relationships between consumers and providers of business services	Phase B
AF.10	Organisational Decomposition Diagram	A list of links between actors, roles, and locations within an organisation tree	Phase B
AF.11	Process Flow Diagram	A model to show sequential flow of tasks within a business process	Phase B

(Continues)

Table 22. *(Continued)*

CODE	ARTEFACT	BRIEF CONTENT	TOGAF ADM PHASE
AF.12	Data Entity/Data Component Catalogue	A list of all the data used across the enterprise, incl. data entities & components	Phase C
AF.13	Data Entity/Business Function Matrix	A list that links data entities and business functions within an organisation	Phase C
AF.14	Data Migration Diagram	A diagram that displays the flow of data from the source to the target applications	Phase C
AF.15	Application Portfolio Catalogue	A catalogue to identify and maintain all the applications in the organisation	Phase C
AF.16	Application/Function Matrix	It links applications and business functions within an organisation	Phase C
AF.17	Application Interaction Matrix	A mapping that describes communications relationships between applications	Phase C
AF.18	Application and User Location Diagram	A diagram to show the geographical distribution of applications	Phase C
AF.19	Application Use-Case Diagram	A diagram to link consumers and providers of application services	Phase C
AF.20	Process/Application Realisation Diagram	A diagram to depict the sequence of events when multiple applications are involved in executing a business process	Phase C
AF.21	Software Distribution Diagram	A diagram to show how physical applications are distributed across physical technology and the location of that technology	Phase C
AF.22	Technology Portfolio Catalogue	A catalogue to identify and maintain all the technology across the organisation	Phase D
AF.23	Application/Technology Matrix	A mapping of applications to technology platform	Phase D
AF.24	Platform Decomposition Diagram	A diagram to cover all aspects of the infrastructure and technology platform	Phase D
AF.25	Processing Diagram	A diagram to show deployable units of code/ configuration and how these are deployed onto the technology platform	Phase D

After introducing the artefact catalogue, the section continues with some preliminary analyses on the applicability of TOGAF artefacts in the proposed framework. *Figure 28* illustrates a sample artefact chain from business goals to underlying IT infrastructure. The structure of the figure can be interpreted as follows: Each element in the chain is supplied with a containing EA artefact. Besides chain artefacts, there are also artefacts between the main elements of the chain, indicating the analytical potential for chain matches. In connection with artefact chains, *Table 23* presents within-layer artefacts according to the necessary architecture domain matches. The table contains those artefacts that are suitable for analysing within-domain architecture connections.

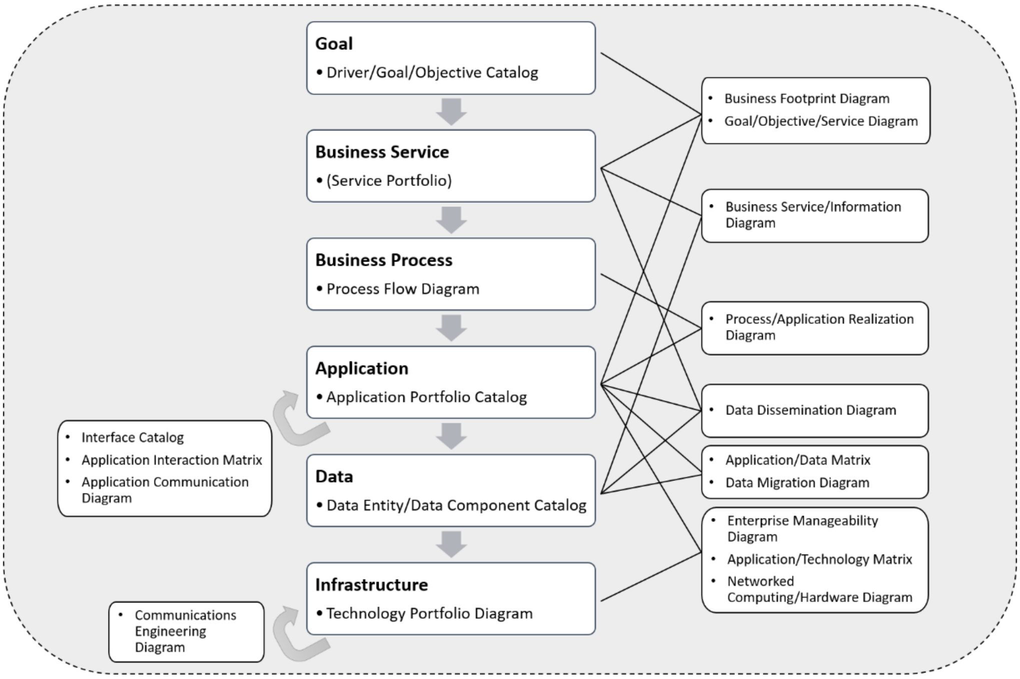


Figure 28. Sample Artefact Chain (based on TOG, 2015)

Table 23. Within-Layer Artefacts (based on TOG, 2015)

DOMAIN MATCHING	ARTEFACT
Business Architecture & Data Architecture Matching	▪ Data Entity/Business Function Matrix ▪ Data Security Diagram ▪ Data Lifecycle Diagram ▪ Data Dissemination Diagram
Business Architecture & Application Architecture Matching	▪ Application/Organisation Matrix ▪ Role/Application Matrix ▪ Application/Function Matrix ▪ Application and User Location Diagram ▪ Process/Application Realisation Diagram ▪ Data Dissemination Diagram
Business Architecture & Technology Architecture Matching	▪ Environments and Locations Diagram ▪ Processing Diagram ▪ Software Distribution Diagram
Data Architecture & Application Architecture Matching	▪ Application/Data Matrix ▪ Data Migration Diagram ▪ Data Dissemination Diagram ▪ Data Security Diagram
Data Architecture & Technology Architecture Matching	▪ Data Security Diagram
Application Architecture & Technology Architecture Matching	▪ Enterprise Manageability Diagram ▪ Software Distribution Diagram ▪ Application/Technology Matrix ▪ Networked Computing/Hardware Diagram ▪ Communications Engineering Diagram ▪ Environments and Locations Diagram ▪ Processing Diagram

The final component of the proposed framework is the catalogue of suitable EA analysis types. EA analysis types are capable of revealing misalignment symptoms in the artefacts. In this research methodology, 8 possible EA analysis types will be used as recommended EA analysis types (*Table 24*). The content of the catalogue was collected from the related literature on EA analysis (Buckl et al., 2009a; Niemann, 2006; Wagter et al., 2012). To ease further reference, EA analysis types are coded.

Table 24. EA Analysis Catalogue (based on Buckl et al., 2009a; Niemann, 2006; Wagter et al., 2012)

Code	EA Analysis Type	Brief Content
A.01	Dependency analysis	Analysis of directly or indirectly linked EA entities, relationship analysis, and impact analysis
A.02	Network analysis	Analysis of EA model network elements and EA domain networks
A.03	Coverage analysis	Analysis of business structure coverage (by supportive application systems)
A.04	Interface analysis	Analysis of interfaces between application systems
A.05	Complexity analysis	Analysis of architecture complexity by architecture components and relationships
A.06	Enterprise interoperability assessment	Analysis of interoperability between architecture entities and architecture domains
A.07	Enterprise coherence assessment	Analysis of coherence between architecture entities
A.08	Heterogeneity analysis	Analysis of IT assets heterogeneity

At the end of the section, the operation of the proposed research methodology will be introduced. The operation results build on the above-introduced framework components. Four traditional alignment perspectives (P.01 Strategy Execution, P.02 Technology Transformation, P.03 Competitive Potential and P.04 Service Level) are analysed according to the approach of the proposed framework. The main steps of operating the framework are presented in *Figure 29*.

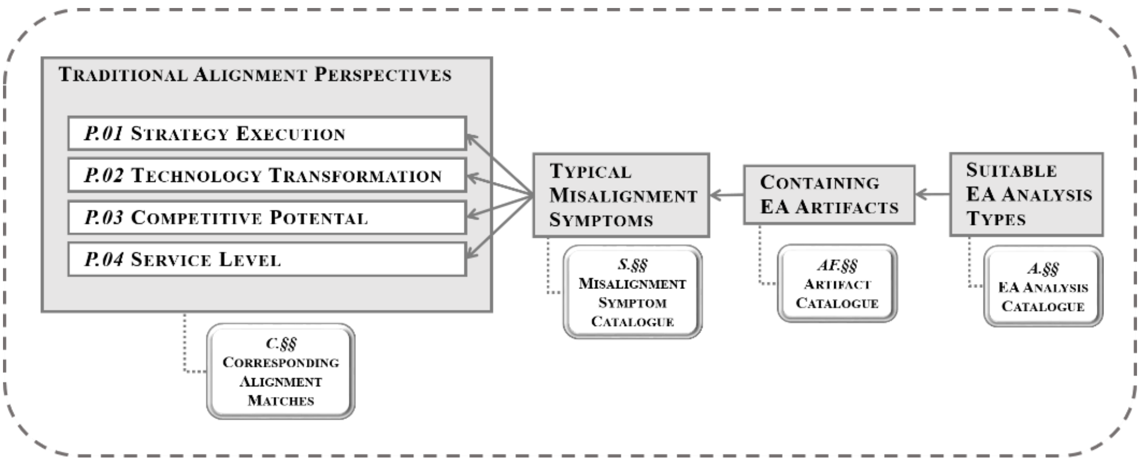


Figure 29. The Operation of Artefact-Based Misalignment Detection Framework

Firstly, some preliminary results will be introduced on the operation of the proposed framework. A thorough matching structure was completed for analysing misalignment symptoms in terms of containing EA models and suitable EA analysis types. In this preliminary result traditional alignment perspectives are analysed according to the following steps: Firstly, alignment perspectives are decomposed into corresponding perspective components, a.k.a. alignment matches (C.§§). Secondly, typical misalignment symptoms are connected to the perspective components using the misalignment symptom catalogue (S.§§) as a reference. Thirdly, relevant containing artefacts are attached to the misalignment symptoms in question. In this step, the artefact catalogue (AF.§§) is used as a reference. Finally, suitable EA analysis types are collected to the containing artefacts, using the EA analysis catalogue (A.§§) as a reference. Preliminary results on this matching are presented in the following structure in *Appendix G*:

- Results of Strategy Execution perspective are shown in *Appendix G, Table G1*. Investigated perspective components include C.01 and C.02.
- Results of Technology Transformation perspective are introduced in *Appendix G, Table G2*. C.03 and C.04 perspective components were analysed in this part.
- Results of Competitive Potential perspective are displayed in *Appendix G, Table G3*. Inspected perspective components include C.01 and C.03.
- Results of Service Level perspective are collected in *Appendix G, Table G4*. This perspective was analysed by C.02 and C.04 perspective components.

Table 25 gives an excerpt from the above-presented matching results for the Strategy Execution perspective.

Table 25. Sample Matching Results for Strategy Execution Perspective

Perspective Component	Misalignment Symptom	Artefact	EA Analysis
C.01 Matching of Business Strategy and Business Structure domains	S.01 Undefined organisational mission, strategy, and goals	AF.06 Business Footprint Diagram	A.03 Coverage analysis
	S.03 Lack of relation between process goals and organisational goals	AF.06 Business Footprint Diagram AF.08 Goal/Objective/ Service Diagram	A.01 Dependency analysis
C.02 Matching of Business Structure and IT Structure domains	S.06 Application functionality does not support at least one business process task	AF.15 Application Portfolio Catalogue AF.16 Application/ Function Matrix	A.01 Dependency analysis
	S.07 Business process task supported by more than one application	AF.15 Application Portfolio Catalogue AF.16 Application/ Function Matrix	A.01 Dependency analysis

Additional preliminary results are available in the field of misalignment symptom categorisation. In this preliminary result, a reduced list of misalignment symptoms was located on the TOGAF metamodel (TOG, 2015). The complete location matching can be found in *Appendix F*. In this section an excerpt is given from the matching experiment. *Table 26* contains a shortened list of the misalignment symptoms, while *Figure 30* proposes the result of the symptom localisation experiment.

Table 26. Excerpt of Misalignment Symptom Catalogue for Localisation (based on Carvalho and Sousa, 2008)

CODE	MISALIGNMENT SYMPTOM
S.01	Unknown process contribution towards organisation goals
S.02	Unknown contribution towards organisation goals
S.03	Unknown responsibilities
S.04	The ultimate responsible for a business process is not known
S.05	Lack of required information to support decision making
S.06	Lack of required information to support day-to-day activities
S.07	Outdated information is found
S.08	Information entities do not have a business actor responsible for its coherency and accuracy
S.09	Time is spent on synchronising data between applications
S.10	Non-automatic data management among application systems

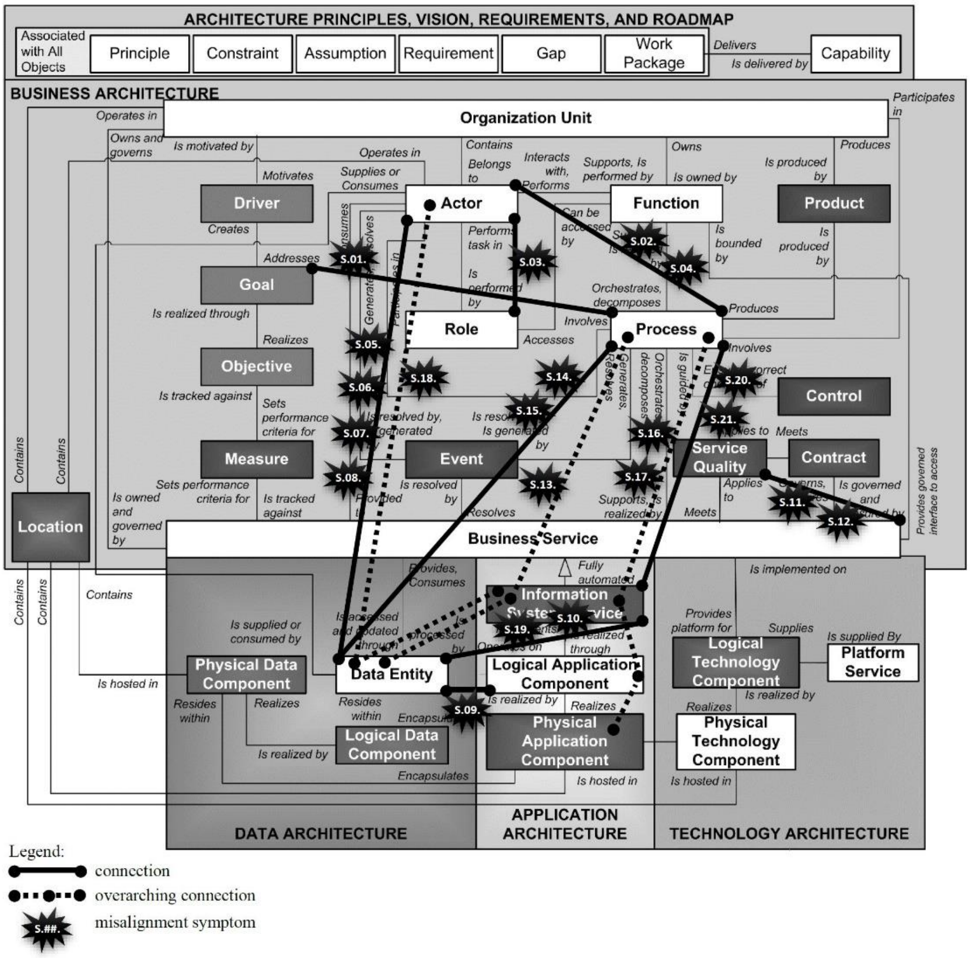


Figure 30. Locating Misalignment Symptoms on TOGAF Metamodel (based on TOG, 2015)

After presenting preliminary results, an extended version will be given about the operation of the proposed framework. *Table 27* contains a framework for identifying symptoms for EA scope analysis and provides three sample analyses of misalignment symptoms. Aspects for analysing symptoms are described and interpreted in the table. This framework concludes with a distinct categorisation of misalignment symptoms, which will be introduced hereafter.

Table 27. A Framework for Identifying Symptoms for EA Scope Analysis

ASPECT	BRIEF DESCRIPTION	SAMPLE MISALIGNMENT SYMPTOMS		
CODE	The corresponding misalignment symptom code from the symptom collection listed before	S.05	S.07	S.14
ALIGNMENT PERSPECTIVE	The corresponding alignment perspective	P.03 Competitive Potential perspective	P.01 Strategy Execution perspective	P.04 Service Level perspective
ALIGNMENT TYPE	The corresponding alignment type, a.k.a. Perspective Component from the Perspective Decomposition table	C.01 Matching of Business Strategy and Business Structure domains	C.02 Matching of Business Structure and IT Structure domains	C.04 Matching of IT Strategy and IT Structure domains
SYMPTOM DEFINITION	Description of misalignment symptom	*Undefined or multiple hierarchy or lines of reporting*	*Business process task supported by more than one application*	*Under capacity infrastructure*
LITERATURE REFERENCE	Reference for misalignment symptom collection in related literature	Carvalho and Sousa, 2008	Sousa et al., 2005	Carvalho and Sousa, 2008
SIGN, PRESENCE	Content and meaning of the symptom, i.e. the way how a symptom can be evinced	Malfunctioning lines of reporting	Business process tasks are supported by more than one supportive application function in a business process model	Capacity problems due to under capacity IT infrastructure
OCCURRENCE, PRESENCE IN EA MODEL	The way the symptom occurs in an EA model, i.e. the	Either undefined or multiple hierarchy or lines of reporting	Sum of supportive application functions exceeds	Insufficient IT capacity, which is not able to deliver the

(Continues)

Table 27. *(Continued)*

Aspect	Brief Description	Sample Misalignment Symptoms		
	contextual sign that indicates the presence of the symptom in an EA model		1 per business process tasks	agreed service level targets
Containing EA Model	The corresponding TOGAF artefact that manifests the symptom	AF.02 Role Catalogue AF.09 Business Use-Case Diagram AF.10 Organisational Decomposition Diagram	AF.15 Application Portfolio Catalogue AF.16 Application/ Function Matrix	AF.24 Platform Decomposition Diagram
Occurrence on Model Entity Level	The corresponding model entity that manifests the symptom	Missing or multiple connections between business roles for reporting line representation	More than 1 application function is connected to business process tasks	Business services and processes supported by underlying IT infrastructure
Other Necessary Sources for Investigation	Other sources, if any, that may be needed for symptom detection, e.g. configuration details, transaction data	Up to date description about lines of reporting	None	Data on IT infrastructure capacity, agreed service levels and the consumption of IT infrastructure

According to the operation of the proposed methodology, misalignment assessment framework presented in *Table 27* can result in three categories of misalignment symptoms (S.C.§§):

S.C.01. Symptoms that can be handled and revealed in EA scope (e.g. S.07)

S.C.02. Symptoms that can be handled in EA scope in a reduced extent, i.e. analytical potential only for simplified, incomplete symptom detection. The symptom loses from its original content, i.e. an in-depth analysis is not performed. However, it is applicable for a preparatory test (e.g. S.05).

S.C.03. Symptoms that cannot be handled and detected solely in EA scope, other information sources are needed for symptom detection. These symptoms will be handled in future work (e.g. S.14).

Table 28 proposes a framework for detecting misalignment symptoms in EA scope. The analysis performed in this table builds only on those symptoms that were identified as manageable symptoms (S.C.01) in the previous operation phase.

Table 28. A Framework for Detecting Misalignment Symptoms in EA Scope

Aspect	Brief Description	Sample Symptom
Code	The corresponding misalignment symptom code from the symptom collection listed before	S.07
Symptom Definition	Description of misalignment symptom	*Business process task supported by more than one application*
Suitable EA Analysis to detect the symptom	Methodological approach chosen for symptom detection	A.01 Dependency analysis
Occurrence, Presence in EA Model	The way the symptom occurs in an EA model, i.e. the contextual sign that indicates the presence of the symptom in an EA model	Sum of applications exceeds 1 per business process tasks
Containing EA Model	The corresponding TOGAF artefact that manifests the symptom	AF.15 Application Portfolio Catalogue AF.16 Application/ Function Matrix
Occurrence on Model Entity Level	The corresponding model entity that manifests the symptom	Application functions connected to business process tasks
Containing EA Model in Organisational Model Structure	The corresponding organisational model that manifests the symptom - Not necessarily equal with 'Containing EA Model' listed before	Business process model
Occurrence, Presence in EA Model of the Organisational Model Structure	The way the symptom occurs in the organisational model - Not necessarily equal with 'Occurrence, Presence in EA Model' listed before	Sum of supportive applications exceeds 1 per business process tasks in a process flow
Occurrence on Model Entity Level in Organisational Model Structure	The corresponding organisational model entity that manifests the symptom - Not necessarily equal with 'Occurrence on Model Entity Level' listed before	Application functions connected to business process tasks
Occurrence in XML-based EA Model Export	The way the symptom can be manifested in XML-based EA model export	Relations between Node type: Business process task and Node type: Application function
Occurrence on Model Entity	The way the symptom can be manifested on model entity level in XML-based	Number of relations between Node type: Business process task and Node type:

(Continues)

Table 28. *(Continued)*

Aspect	Brief Description	Sample Symptom
Level in XML Export	EA model export, i.e. the XML entities that manifest the symptom	Application function per Node type: Business process task
XML-based Query	General query for misalignment symptom detection using evincing XML entities	For every node where node type = business process task: - Numerate node relations where node type = application function - Alert business process task nodes with >1 application function connections
Query in Schematron Language	Query in Schematron language using the grammar of the pattern-based query language	<pattern name="S.07. Business process task supported by more than one application"> <rule context="Object Definition[@Node Type='{*business process task*}']"> <report test="count(Connection Definition[@ToObjectDefinition.IdRef=parent::Object Definition/following-sibling::Object Definition[@Node Type='{*application function*}']/@ObjectDefinition.ID or @ToObjectDefinition.IdRef=parent::ObjectDefinition/preceding-sibling::ObjectDefinition[@Node Type='{*application function*}']/@ObjectDefinition.ID])>1">Alert: S.07. Business process task supported by more than one application </report> </rule> </pattern>

Based on the proposed framework for identifying symptoms for EA scope analysis (*Table 27*) and the framework for detecting misalignment symptoms in EA scope (*Table 28*), misalignment symptoms will be translated into analysable rules, and finally into queries for detection. Symptom-rule transformation will be based on the corresponding aspects of the framework for identifying symptoms for EA scope analysis (*Table 27*) and the framework for detecting misalignment symptoms in EA scope (*Table 28*). Queries for detecting the symptoms in EA models also stem from the corresponding aspects of the latter framework (e.g. Occurrence in EA model, Occurrence on model entity level and the same aspects for XML exports). The XML-based query originates from the previous analysis results of the framework. Finally, the skeleton of the query in Schematron language provides the specific query for the symptom.

Implementation details of operating the proposed framework will be summarised briefly in the following parts of the section. Queries will be written by using the XPath language and the Schematron language. Schematron language will be used for making assertions about patterns (i.e. misalignment symptoms) found in the XML exports of the EA models. *Appendix J* contains the basic elements of Schematron language. Contrary to Schematron language, which is referred to as the language of writing assertions, XPath language serves as a supportive language for defining the context of the queries. Nodes in the XML exports will be reached by using XPath expressions, i.e. XPath expressions will be used to navigate through nodes and attributes in the XML exports. Queries will use the syntax of XPath for defining the corresponding parts of the XML exports. XPath expressions will be embedded into the Schematron queries. XPath will be used both in context setting (where the node under analysis is determined) and testing (where the logical expression of detecting the symptom is defined). *Appendix K* contains the main XPath operators for Schematron queries. Schematron-based queries with embedded XPath expressions will be written and later validated in an XML validation tool, namely the Oxygen XML Editor v18.0. The XML editor includes an editor for writing Schematron queries as well as an inbuilt validator engine for validating XML documents against a Schematron rule. Assertions reported by the validation engine will also be displayed by the editor. Examples of using the languages and the XML editor will be presented in detail in the next section.

After introducing the proposed analytical framework for EA-based misalignment assessment, the section concludes with some details on data collection, data analysis, and result interpretation.

Data collection: Data will be collected according to the recommendations of the Design Science Research and the Case Study Research methods. Suitable test organisations will be identified to be the subjects of the proposed analysis. The organisational models (process models, organisational charts, process maps, balanced scorecards, value chain diagrams, etc.) of the chosen test organisations will serve as input data. Besides the collection of organisational models, semi-structured interviews will be performed in order to collect further information about the organisational context of the models.

Data analysis: By means of case generation, the data collected in the previous phase will be analysed. Proposed steps of data analysis include research steps introduced in the previous subsections. In summary, organisational models of the test organisations will be transformed into EA models. The symptoms of misalignment will be detected in the structured XML exports of EA models by rule construction and rule testing techniques.

Plan for Interpreting Results: Data analysis phase will provide us with a certain amounts of structured data on identified misalignment symptoms. In the result interpretation phase, these data will be construed and processed. Based on the rule construction phase, rule testing approaches will be used to identify formally described misalignment symptoms in the EA models. On the basis of the rule testing phase, results will be interpreted in terms of the alignment-misalignment continuum. First, processed and tested rules will be converted back into misalignment symptoms. This step is vital for the proper interpretation of the detected symptoms. Secondly, the location of the identified symptoms will be analysed. This step provides information about the location of badly-working routines both from physical and logical perspectives. Finally, re-alignment activities will be recommended according to the nature and location of the detected misalignment symptoms. The proposed framework will be tested and validated at test organisations in order to confirm the relevance of the results. Via analysing real enterprise architecture models, examples will be given to demonstrate the applicability as well as the operation of the framework.

This section has introduced the research methodology and proposed the research framework. In the next section, a case study will be presented in detail to demonstrate the operation of the proposed research framework.

4 CASE STUDY: ROAD MANAGEMENT AUTHORITY

To demonstrate the applicability of the proposed framework as well as to better understand how it works in practice, a case study has been conducted. The case study clarifies the operation of the framework by applying it in the context of a real EA model structure. The empirical investigation focuses on a Hungarian road management authority. The study was carried out on a fragment of the road management authority's EA model structure. It describes a road control initiative, showing the relevant EA models and artefacts to be modified during the progression of the project.

The section first introduces the organisation and the project under review. It is followed by an outline of the EA model structure with a special focus on the model environment of the road control initiative. After presenting the model base, results from preliminary reviews are documented. It is followed by a detailed analysis on misalignment symptoms. The next section deals with the process of misalignment symptom detection at the road management authority. Subsequently, detection results are interpreted in detail. At the end of the section, results are discussed and conclusions are drawn about the relevance and significance of the research framework in operation.

4.1 Case Introduction

The road management authority is a non-profit government corporation that handles matters relating to road safety, road traffic management, and transportation for around 32,000 kilometres of a national public road network. The scope of activities spans from road operation and road maintenance over professional services to providing road information. Road-related activities consist of road condition checking, pavement maintenance and reparation, roadside maintenance, off-pavement landscape maintenance, snow removal and de-icing of roads and the installation, reparation, and replacement of traffic engineering devices. Professional services consist of the management of road operator licenses, road network protection, quality control and maintaining the national road register. In its actual form, the authority was set up in 2006 as a successor to a previous road management government authority. Its headquarters and three sites are located in Budapest, and the authority has approx. 170 branches around Hungary. In 2016, the authority employed around 8,200 employees.

The authority is governed by a chief executive officer. There are two deputy managers: 1) for engineering and 2) for management. The former has control over 3 directorates: 1) the public road service provider, 2) the directorate of maintenance and 3) the directorate for development and restoration for public roads and bridges. The latter has control over the fields of finance, accounting, management control, and planning. There are also directorates for corporate governance, human resources, IT, procurement, law and facility management. Quality control laboratories operate under the supervision of a public road service provider. Under the maintenance directorate, there are 19 county directorates as well.

The value chain of the authority consists of primary, support and governance activities. Primary activities include operation, maintenance, implementation, engineering and business services related to road management, public duties, business activities and other sales activities. Support activities consist of management, human resources, engineering support, IT and project management. Governance activities include strategic management and road-related management.

This subsection described the case organisation with main characteristics, activities, organisational structure and business processes. The following subsection introduces the road control initiative at the road management authority with special attention to project drivers, project objectives, requirements, and constraints.

4.2 Road Control Initiative

Road control initiative is a pilot project for setting up EA practice in the authority. The initiative is part of an integrated road network development project which aims to transform the internal operation as well as to optimise processes in order 1) to increase operational efficiency and transparency within the road management authority, 2) to achieve cost-efficient public task execution, 3) to provide a nation-wide integrated management system, 4) to increase access to management information, 5) to create the premises for standardised services, 6) to increase traffic safety.

As part of the above introduced integrated road network development project, the road control project is concerned with the implementation of a traveling warrant system. The goal of the project was manifold:

- to achieve real-time road control information forwarding,
- to deliver up-to-date information and control specifications onboard,
- to provide exact information retrieval about past activities and coordinates by place and by date,
- to provide electronic administration about road control,
- to provide an expandable and integral solution for road control support,
- to decrease paper administration related to road control tasks.

The project was set up to eliminate the following problems related to the previous road control solution:

- administration overload,
- too many isolated information systems,
- slow escalation of road control-related information,
- non-automated read-in of road control-related data,
- non-electronic retrieval of previous road control routes and coordinates.

The drivers of the project arose from the problems related to the previous implementation, namely:

- to avoid redundant data recording,
- to get an up-to-date master data register,
- to achieve lower maintenance and development costs,
- to achieve lower exposure to suppliers,
- to increase profitable duty time,
- to provide fast, route-based information retrieval,
- to decrease administration overload,
- to provide the opportunity for online intervention.

The requirements of the project consisted of the following criteria: 1) compliance with architectural principles, 2) the administration of the road control process with electronic forms,

3) to support the process in a closed manner, 4) to exploit the integrated capabilities of the to-be road control system. Finally, the project was constrained by the following conditions: 1) compliance with road control regulations, 2) high availability owing to dependencies among integrated components, 3) compliance with the criteria of public procurement, 4) proclamation of strict rules and conditions.

The road control project was set up to outline the process of road control with EA methods over 2 sets of changes. The as-is state presents the actual state of road control activities. To-be No. 1 and To-be No. 2 phases deal with the changes in process execution, supportive applications, and underlying technological infrastructure.

This subsection introduced the road control initiative as part of a broader transformation programme. The section continues with some details on the modeling environment.

4.3 EA Model Structure

This subsection describes the EA model structure at the road management authority. The subsection first introduces the general model structure. It is followed by a focused review of the model structure of the road control initiative. In general EA models at the road management authority are generated according to the rules of ArchiMate language and ARIS EPC-s. Models are created in ARIS by using the methodology of TOGAF ADM.

The general model structure at the road management authority consists of several layers. *Table 29* introduces the model structure with layers, categories, and main model contents. As we can see, there are some modeling resources available concerning the Business Architecture (Layer 0-2, 5), Data Architecture (Layer 3) and Application Architecture (Layer 4), but there is no modeling instance for technological/infrastructural projection of the organisation.

Table 29. Model Structure at the Road Management Authority

LAYER	CATEGORY	ORGANISATIONAL MODELS
0	*Strategy*	▪ Business Function – IT System Matrix ▪ Business Process Map ▪ Architectural Principles Catalogue
1	*Organisational Structure*	▪ Organigram

2	*Business Processes*	▪ Value Chain Diagram
		▪ Business Process Models
		    ▪ Primary Activities
		    ▪ Support Activities
		    ▪ Governance Activities

3	*Data*	▪ Regulations ▪ Data Components ▪ Document Model
4	*Applications*	▪ Application Portfolio ▪ Application Type – Application Component Matrix ▪ Data Flow Diagram (Data Flow between Main IT Systems) ▪ Application Cooperation Diagrams ▪ Interface Diagram
5	*Products and Services*	▪ Service Map

As for the model structure of the road control initiative, *Figure 31* and *Table 30* present some details. *Figure 31* shows the investigated EA model structure in the road control initiative. It is considered a metamodel for artefacts under review. The model structure consists of 4 EA domains: Business Architecture, Data Architecture, Application Architecture, and Technology Architecture. These domains are connected to the corresponding TOGAF ADM phases. (Note that there are also models for Technology Architecture, while the general model structure did not contain a technological layer.) EA domains contain several artefacts, indicated as rectangles in the figure. Colors of the rectangles reflect the assignment to TOGAF ADM phases. As can be seen, the available models are only a fragment from the complete TOGAF artefact collection. Artefacts are connected with each other according to the relationships in content between EA models/artefacts. There are both between-layer and within-layer artefact connections in the model structure.

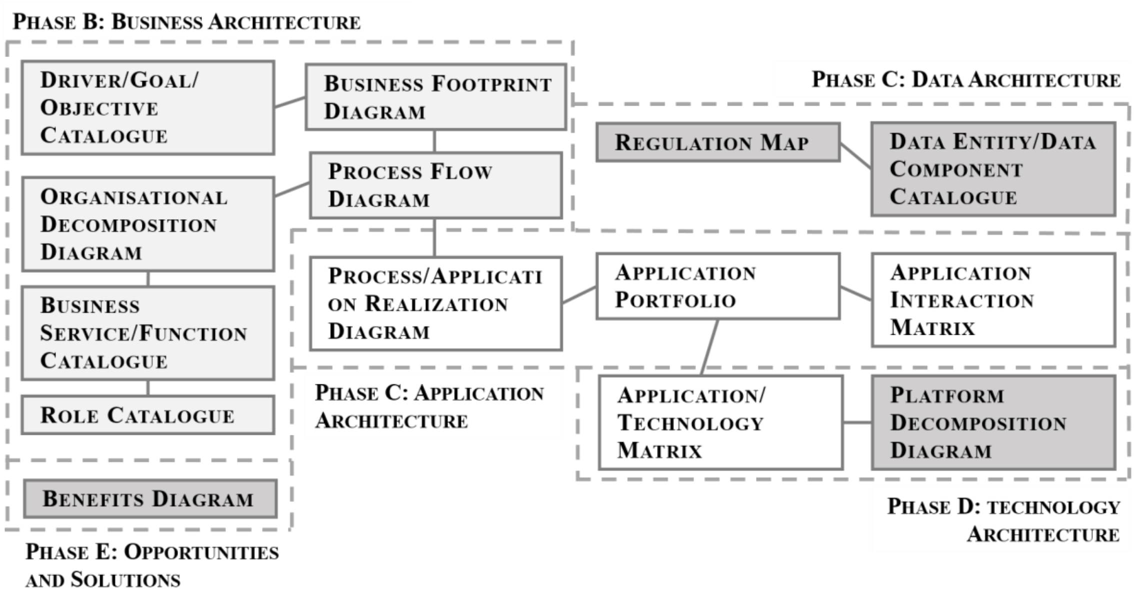


Figure 31. EA Model Structure in the Road Control Initiative

Table 30 lists the brief content of each EA model element. This collection assigns the available EA models at the road management authority to formal TOGAF artefacts and to ArchiMate viewpoints. Except for the Regulation Map, the EA model list follows the original TOGAF artefact base. The model structure in the road control initiative offers an in-depth analytical potential for EA-based misalignment assessment. The small size and the compact nature of the project ensure minimal, but sufficient validation of the proposed framework.

Table 30. EA Model Contents in the Road Control Initiative

ADM Phase	Artefact	Brief Description
Phase B	*Driver/Goal/ Objective Catalogue*	*Viewpoint: Organisation* A breakdown of road control drivers, goals, and objectives to provide a cross-organisational reference of driver fulfillment
Phase B	*Business Footprint Diagram*	*Viewpoint: Layered View* A mapping of business goals, organisational units, business functions, business services, and delivering technical components of the road control initiative
Phase B	*Organisational Decomposition Diagram*	*Viewpoint: Organisation* A list of links between actors, roles, and locations within a road control organisation structure
Phase B	*Process Flow Diagram*	*Viewpoint: Business Process* A model to show sequential flow of tasks within business processes taking part in road control tasks
Phase B	*Business Service/Function Catalogue*	*Viewpoint: Business Process* A functional decomposition to identify capabilities concerning road control tasks
Phase B	*Role Catalogue*	*Viewpoint: Organisation* A list of all authorisation levels at the road control initiative
Phase C	*Regulation Map*	*Viewpoint: Information Structure* A list of relevant regulations for the road control initiative
Phase C	*Data Entity/Data Component Catalogue*	*Viewpoint: Information Structure* A list of all the road control data used across the authority, incl. data entities and components
Phase C	*Process/Application Realisation Diagram*	*Viewpoint: Application Usage* A model to depict the sequence of events when multiple applications are involved in executing road control tasks
Phase C	*Application Portfolio*	*Viewpoint: Application Usage* A catalogue to identify and maintain all the applications in the road control initiative
Phase C	*Application Interaction Matrix*	*Viewpoint: Application Co-operation* A mapping that describes those communication relationships between applications that are relevant to the road control initiative
Phase D	*Application/ Technology Matrix*	*Viewpoint: Infrastructure Usage* A mapping of road control applications to relevant technology platform
Phase D	*Platform Decomposition Diagram*	*Viewpoint: Infrastructure Usage* A model to cover all aspects of the infrastructure and technology platform concerned with road control at the authority
Phase E	*Benefits Diagram*	*Viewpoint: Implementation and Deployment* A list of opportunities and benefits to support selection and prioritisation of road control decisions - It also contains the working breakdown structure of related projects with goal fulfilments

After briefly summarising the model contents in the road control initiative, EA model variants will be presented. *Table 31* deals with the substantial EA models with model variants presenting the transition during project execution. Some models have all three variants: Original Version (indicated as OV), To-Be 1.0 (indicated as 1.0) and To-Be 2.0 (indicated as 2.0). Other models lack the original version of the model, while there are merged models as well, indicated as 1.0-2.0 in the table. EA models without indicated model variants consist of constant model content without any change during process execution.

Table 31. EA Model Variants in the Road Control Initiative

EA MODEL	MODEL VARIANTS
Road Control System with Relations	*1.0 and 2.0*
Road Control System with Infrastructure	*1.0 and 2.0*
Road Control Roles and Reporting Lines	-
Road Control System with Services	*1.0 and 2.0*
Road Control Process	*OV, 1.0 and 2.0*
Road Control Data Model	*OV, 1.0 and 2.0*
Road Control System 2.0 Introduction	-
Road Control Regulation Map	*OV and 1.0-2.0*
Road Control 1.0 and 2.0 Goal Map	-
Road Control 1.0 and 2.0 Implementation Plan	-
Road Control Process 1.0 and 2.0 with Business Services	-
Road Control System Infrastructure Usage Model	*1.0 and 2.0*
Technological Hardware Components	-
Technological Software Components	-

The actual model base in the road control initiative (*Table 31*) is followed by an analysis on containing model elements in the available EA models. First, emerging model elements are listed with an abbreviated form (*Table 32*) to ease readability. The list arises from the entity list of the of the ArchiMate language.

Table 32. List of Emerging Model Elements in the Road Control Initiative

ABBREVIATION	MODEL ELEMENT	ABBREVIATION	MODEL ELEMENT
AC	Application Component	Dev	Device
AF	Application Function	DO	Data Object
AI	Application Interface	Dr	Driver
Ar	Artefact	Go	Goal
As	Assessment	Gr	Group
AS	Application Service	IS	Infrastructure Service
BA	Business Actor	L	Location
BC	Business Collaboration	N	Node
BE	Business Event	Nw	Network
BO	Business Object	Pl	Plateau
BP	Business Process	Pr	Principle
BRe	Business Regulation	Rep	Representation
BRo	Business Role	Req	Requirement
BS	Business Service	S	Stakeholder
C	Constraint	SS	System Software
Del	Deliverable	W	Work Package

The list of emerging model elements is followed by a matrix of the contained model elements in the different EA model variants (*Table 33*). Rows in the matrix contain the model variants, while columns contain the model elements in abbreviated form. Cells in the matrix represent a possibility of the model variant to contain a particular model element. In this sense, an X in the cell represents that a particular model variant contains a particular model element.

Table 33. Model Elements in Use in the EA Model Variants

Object / EA Model	BO	Do	Rep	Bre	AC	AF	AI	AS	L	Dev	Ne	IS	No	SS	BC	Bro	BA	BP	BE	BS
Road Control System 1.0 with Relations		X			X	X														
Road Control System 2.0 with Relations		X			X	X	X	X												
Road Control System 1.0 with Infrastructure									X	X	X	X	X	X						
Road Control System 2.0 with Infrastructure									X	X	X	X	X	X						
Road Control Roles and Reporting Lines									X						X	X	X			
Road Control System 1.0 with Services						X												X	X	
Road Control System 2.0 with Services					X	X												X	X	
Road Control Process Original Version																				
Road Control Process 1.0	X														X	X		X	X	
Road Control Process 2.0	X														X	X		X	X	
Road Control Data Model Original Version	X	X	X																	
Road Control Data Model 1.0	X	X	X																	
Road Control Data Model 2.0	X	X	X																	
Road Control System 2.0 Introduction					X	X						X	X	X	X	X		X	X	X
Road Control Regulation Map Original Version				X																
Road Control 1.0 and 2.0 Regulation Map				X																
Road Control Process 1.0 and 2.0 with Business Services	X														X	X		X	X	X
Road Control System 1.0 Infrastructure Usage Model					X							X	X	X						
Road Control System 2.0 Infrastructure Usage Model					X							X	X	X						
Technological Hardware Components										X										

Object / EA Model	AC	SS	S	Dr	As	Ar	Go	Gr	Pr	Req	C	Pl	Del	W	No	AI	BC	Bro	BA	BP
Road Control 1.0 and 2.0 Goal Map			X	X	X		X		X	X	X									
Road Control 1.0 and 2.0 Implementation Plan	X						X					X	X	X						
Technological Software Components		X				X		X												

According to the previously introduced model element matrix, EA model relationships can be established. Columns of the matrix represent the possible connections between EA model variants. *Figure 32* depicts the connections between EA models in the road control initiative. In this form model variants are aggregated, i.e. there is no distinction between model variants. Therefore, the figure presents the connections between any of the model variants of the particular EA model. As can be seen, the models of Road Control Process with Business Services as well as Road Control System with Relations have several connections with other EA models. There are also marginal models in the figure, e.g. the models of Technical Hardware Components and Road Control Goal Map.

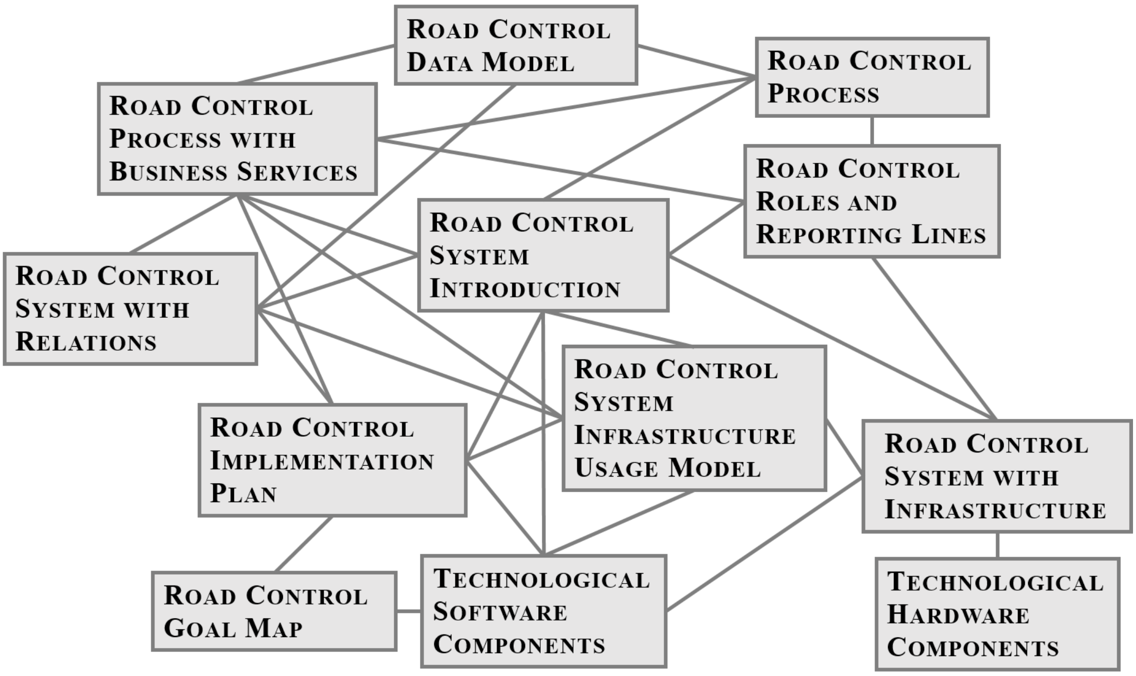


Figure 32. EA Model Connections in the Road Control Initiative

The subsection introduced the model structure at the road management authority with a special focus on the model base of the road control initiative. In the following section, preliminary reviews will be documented which aimed to revise the actual state of the initiative together with supposed, hypothetic alignment problems.

4.4 Preliminary Review

Before commencing misalignment symptom detection at the case organisation, preliminary reviews were organised in order to get acquainted with the conditions in the organisational state. Preliminary reviews were conducted by interviewing stakeholders of the initiative. Interviews served as an initial consultation about influential areas to review and the perceived problems concerning business-IT alignment.

Based on the previously introduced, influential areas to review (*Table 15*), an initial assessment has been conducted to get a comprehensive picture about business and IT operation and relationships at the case organisation. *Figure 33* summarises the influential areas under review. The most important organisational areas that have been comprehended at the road management authority before proceeding business-IT assessments included: 1) Business Strategy, 2) Business Functions, 3) Business Roles, 4) Business Process Map and Business Process Models, 5) IT

Strategy, 6) IT Process Map and IT Process Models, 7) Application Portfolio and Application Interfaces, 8) IT Service Portfolio and Service Catalogue, 9) available EA Models, 10) Architecture Repository, 11) Architecture Maturity and EA Model Reliability, 12) Business/IT Ideas, Propositions and Innovation, 13) Investment Planning. The list of review areas follows the categorisation of *Table 14* introduced in the previous section.

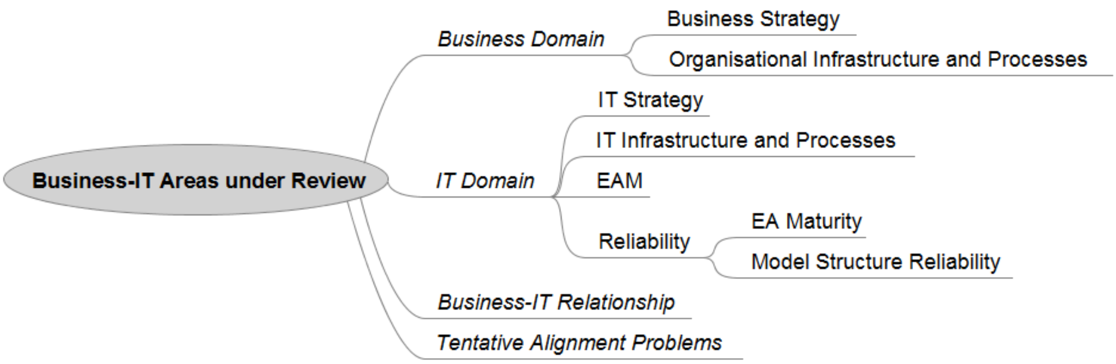


Figure 33. Business-IT Areas under Review at the Road Management Authority

The previously introduced business-IT areas under review and precursory interviews on malfunctioning structures have revealed several problematic business-IT areas and therefore provided us with preliminary assumptions on alignment problems and possible organisational areas for misalignment investigations. An initial list of problematic business-IT areas is referred to as a prefatory step for operating the proposed framework. According to the precursory interviews, *Table 34* introduces the collection of malfunctioning, problematic business-IT areas in the road control initiative. At this point, the list serves as an initial picture about perceived alignment problems. The list will be translated into misalignment symptoms in the following subsection. To ease further reference, perceived problems are coded. M stands for malfunctioning area, and the numbering eases traceability.

Table 34. Assumed Problems and Malfunctioning Areas at the Road Management Authority

CODE	MALFUNCTIONING AREA
M.01	Missing business process owners (occasionally)
M.02	Undefined organisational mission, strategy, and goals
M.03	There are application components that are not used in any business process
M.04	There are out of date technological elements in the IT infrastructure
M.05	There are some business process tasks that are supported by several applications
M.06	Poor IT resources
M.07	Missing competencies to develop or innovate
M.08	Insufficient IT planning processes and IT portfolio management
M.09	Capacity problems concerning IT infrastructure
M.10	Unsatisfactory systems performance monitoring
M.11	Heterogeneous elements in IT infrastructure
M.12	There are information consistency and data integrity problems
M.13	Multiple reporting lines
M.14	There are incompatible platforms in the IT infrastructure

(Continues)

Table 34. *(Continued)*

CODE	MALFUNCTIONING AREA
M.15	Missing data owners
M.16	There are data entities that are not used in any business process
M.17	There are missing application interfaces
M.18	Non automatic data migration among applications
M.19	Lack of architectural integration
M.20	Missing Service Level Agreements
M.21	The same user is managed differently in different applications

This subsection has documented the preliminary interviews together with the presentation of business-IT areas under review at the road management authority. In addition, it has revealed several perceived problems regarding business-IT linkage with projection to organisational areas to conduct misalignment investigations. The subsection will be followed by an in-depth analysis of misalignment symptoms by means of operating the proposed research framework.

4.5 Misalignment Symptom Analysis

Preliminary reviews on the case consisted of the list of influential areas to review and the analysis of assumed malfunctioning areas. These precursory steps are followed by preliminary analytical procedures for misalignment symptom detection. These steps are necessary to prepare the case organisation for operating the proposed research framework. The section commences with an initial assignment in which malfunctioning areas are translated into the corresponding records in the misalignment symptom catalogue. This translation is followed by an EA layer-based analysis of the translated misalignment symptoms, i.e. perceived problems are connected to the appropriate EA layers which are affected in the subsequent misalignment symptom detection. The section continues with the categorisation of perceived misalignment symptoms (S.C.01-S.C.03 categorisation according to the analytical tool proposed in *Table 27*). In this part of the section non-analysable (S.C.03) symptoms are excluded from further analysis. The necessary justifications for excluding these symptoms will also be given in this part. The remaining S.C.01 and S.C.02-type symptoms will be analysed according to the corresponding analytical tool from the proposed research framework (*Table 28*). The section ends with the documentation of general queries for misalignment symptom detection.

In order to prepare for misalignment symptom analysis, perceived malfunctioning areas are translated into misalignment symptoms using the proposed misalignment symptom catalogue. *Table 35* contains the malfunctioning areas and the corresponding misalignment symptoms. Malfunctioning areas are coded according to the previous list (*Table 34*). Misalignment symptoms are coded according to the previously introduced misalignment symptom catalogue (*Table 21*).

Table 35. Translation of Malfunctioning Areas into Misalignment Symptoms

CODE	MALFUNCTIONING AREA	CODE	MISALIGNMENT SYMPTOM
M.01	Missing business process owners (occasionally)	*S.02*	Undefined business process goals, business process owners
M.02	Undefined organisational mission, strategy, and goals	*S.01*	Undefined organisational mission, strategy, and goals

(Continues)

Table 35. *(Continued)*

CODE	MALFUNCTIONING AREA	CODE	MISALIGNMENT SYMPTOM
M.03	There are application components that are not used in any business process.	*S.06*	Application functionality does not support at least one business process activity
M.04	There are out of date technological elements in the IT infrastructure	*S.16*	Out of date technological infrastructure
M.05	There are some business process tasks that are supported by several applications	*S.07*	Business process task supported by more than one application
M.06	Poor IT resources	*S.10*	Insufficient IT resources
M.07	Missing competencies to develop or innovate	*S.12*	Lack of skills to develop or innovate certain types of products
M.08	Insufficient IT planning processes and IT portfolio management	*S.13*	Poor IT planning and portfolio management
M.09	Capacity problems concerning IT infrastructure	*S.14*	Under capacity infrastructure
M.10	Unsatisfactory systems performance monitoring	*S.15*	Lack or poor systems performance monitoring
M.11	Heterogeneous elements in IT infrastructure	*S.17*	Technological heterogeneity
M.12	There are information consistency and data integrity problems	*S.20*	Information consistency or integrity problems
M.13	Multiple reporting lines	*S.05*	Undefined or multiple hierarchy or lines of reporting
M.14	There are incompatible platforms in the IT infrastructure	*S.18*	Incompatible platforms or technologies
M.15	Missing data owners	*S.32*	Lack of data ownership
M.16	There are data entities that are not used in any business process	*S.52*	Not all data entity attributes are read at least by one process
M.17	There are missing application interfaces	*S.39*	Lack of application interfaces
M.18	Non-automatic data migration among applications	*S.57*	The data management should be automatic among the application systems
M.19	Lack of architectural integration	*S.27*	No formal architectural integration at functional organisation level
M.20	Missing Service Level Agreements	*S.24*	Sporadically existing or Technical Service Level Agreements
M.21	The same user is managed differently in different applications	*S.38*	Users managed differently in different applications

The section continues with an EA layer-based categorisation of perceived misalignment symptoms. *Table 36* contains misalignment symptoms and the necessary EA layers under review. This categorisation will guide the symptom detection in the subsequent section. In addition, it helps to understand the nature and scope of perceived misalignment symptoms in the case organisation.

Table 36. Perceived Misalignment Symptoms and Affected Enterprise Architecture Layers

Code	Misalignment Symptom	Affected Enterprise Architecture Layer
S.01	Undefined organisational mission, strategy, and goals	Business Architecture
S.02	Undefined business process goals, business process owners	Business Architecture
S.05	Undefined or multiple hierarchy or lines of reporting	Business Architecture
S.06	Application functionality does not support at least one business process activity	Business Architecture, Application Architecture
S.07	Business process task supported by more than one application	Business Architecture, Application Architecture
S.10	Insufficient IT resources	Technology Architecture
S.12	Lack of skills to develop or innovate certain types of products	Business Architecture
S.13	Poor IT planning and portfolio management	Business Architecture, Application Architecture
S.14	Under capacity infrastructure	Technology Architecture
S.15	Lack or poor systems performance monitoring	Technology Architecture
S.16	Out of date technological infrastructure	Technology Architecture
S.17	Technological heterogeneity	Technology Architecture
S.18	Incompatible platforms or technologies	Technology Architecture
S.20	Information consistency or integrity problems	Data Architecture
S.24	Sporadically existing or Technical Service Level Agreements	Technology Architecture
S.27	No formal architectural integration at functional organisation level	Business Architecture, Data Architecture, Application Architecture, Technology Architecture
S.32	Lack of data ownership	Data Architecture
S.38	Users managed differently in different applications	Application Architecture
S.39	Lack of application interfaces	Application Architecture
S.52	Not all data entity attributes are read at least by one process	Business Architecture, Application Architecture
S.57	The data management should be automatic among the application systems	Data Architecture, Application Architecture

Perceived alignment problems are analysed according to the previously introduced misalignment symptom categorisation scheme. *Table 37* represents symptom categories for each assumed alignment problem. The categorisation stems from symptom categorisation scheme introduced in the research methodology section, viz.:

S.C.01. Symptoms that can be managed and detected in EA scope.

S.C.02. Symptoms that can be managed in EA scope in a reduced extent, i.e. analytical potential only for simplified, incomplete symptom detection.

S.C.03. Symptoms that cannot be managed and detected solely in EA scope, other information sources are needed for symptom detection. These symptoms will be handled in future work.

The following analysis forms limitations for framework applicability i.e. detects those symptoms that cannot be handled within EA scope. Thus, misalignment symptoms under the category of S.C.03 will not be analysed with the proposed research framework. These types of alignment problems are indicated with a light gray background in *Table 37*.

Table 37. Misalignment Symptom Categorisation for Perceived Misalignment Symptoms

CODE	MISALIGNMENT SYMPTOM	SYMPTOM CATEGORY
S.01	Undefined organisational mission, strategy, and goals	S.C.02
S.02	Undefined business process goals, business process owners	S.C.01
S.05	Undefined or multiple hierarchy or lines of reporting	S.C.01
S.06	Application functionality does not support at least one business process activity	S.C.03
S.07	Business process task supported by more than one application	S.C.01
S.10	Insufficient IT resources	S.C.03
S.12	Lack of skills to develop or innovate certain types of products	S.C.03
S.13	Poor IT planning and portfolio management	S.C.03
S.14	Under capacity infrastructure	S.C.03
S.15	Lack or poor systems performance monitoring	S.C.03
S.16	Out of date technological infrastructure	S.C.01
S.17	Technological heterogeneity	S.C.02
S.18	Incompatible platforms or technologies	S.C.01
S.20	Information consistency or integrity problems	S.C.03
S.24	Sporadically existing or missing Technical Service Level Agreements	S.C.03
S.27	No formal architectural integration at functional organisation level	S.C.03
S.32	Lack of data ownership	S.C.01
S.38	Users managed differently in different applications	S.C.03
S.39	Lack of application interfaces	S.C.02
S.52	Not all data entity attributes are read at least by one process	S.C.01
S.57	The data management should be automatic among the application systems	S.C.03

The categorisation table contains misalignment symptoms under the categories of S.C.01, S.C.02, and S.C.03. Misalignment symptoms under the category of S.C.01 and S.C.02 will be further analysed to prepare them for misalignment symptom detection. Misalignment symptoms under the category of S.C.03 will be excluded from further analysis. In this part of the section, a succinct justification will be given to each excluded misalignment symptom. *Table 38* summarises the causes of exclusion. The categorisation of the misalignment symptoms marked for S.C.03 is not generally determined, i.e. it is only valid for the particular case organisation and the selected road control initiative under review. *Table 38* details the specified justifications for the excluded symptoms in this particular analysis example.

Table 38. Justifications for Excluding Misalignment Symptoms under the category of S.C.03

CODE	MISALIGNMENT SYMPTOM	SYMPTOM CATEGORY	JUSTIFICATION FOR EXCLUSION
S.06	Application functionality does not support at least one business process activity	S.C.03	The model base of the case organisation does not contain a specified catalogue about application functionalities for each application in use. For this reason, the symptom cannot be validated against the model base of the case organisation.
S.10	Insufficient IT resources	S.C.03	The modeling of Technology Architecture does not provide the adequate depth of analysis for these kinds of malfunctions.
S.12	Lack of skills to develop or innovate certain types of products	S.C.03	There is no sign of competency and skill catalogue on EA modeling level. The catalogue of skills in product innovation is not followed up in the modeling environment.
S.13	Poor IT planning and portfolio management	S.C.03	There is no instance about the performance and quality of the corresponding processes on EA modeling level.
S.14	Under capacity infrastructure	S.C.03	Based on the fundamental nature of EAM, EA modeling is not capable of tracking capacity levels and violations. There are other dedicated processes to manage these types of malfunctions.
S.15	Lack or poor systems performance monitoring	S.C.03	There is no instance of the corresponding process and its performance on EA modeling level.
S.20	Information consistency or integrity problems	S.C.03	EA modeling is by nature not capable of tracking malfunctions of information integrity. There are other dedicated processes to manage these types of malfunctions.
S.24	Sporadically existing or missing Technical Service Level Agreements	S.C.03	There is a dedicated process to manage these types of malfunctions. EA modeling is by nature not capable of tracking malfunctions in the service level management process.
S.27	No formal architectural integration at functional organisation level	S.C.03	The available fragment of EA models does not provide the necessary analytical depth for this type of symptom.
S.38	Users managed differently in different applications	S.C.03	The available fragment of EA models does not provide the necessary analytical depth for this type of symptom.
S.57	The data management should be automatic among the application systems	S.C.03	EA modeling is by nature not capable of tracking malfunctions in application architecture-wide data management. There are other dedicated processes to manage these types of malfunctions.

Misalignment symptoms not under the category of S.C.03 will be analysed with the proposed research framework. The above-introduced list (*Table 37*) contains 10 analysable alignment problems, both from the categories of S.C.01 and S.C.02. *Tables 39-48* summarise the results of identifying symptoms for EA scope-analysis for every analysable alignment problems. The following assessment is based on the previously introduced scheme for identifying misalignment symptoms for EA scope analysis (*Table 27*).

First, misalignment symptom S.01 Undefined organisational mission, strategy, and goals will be subject to the analysis of EA-scope applicability. *Table 39* contains the analysis details of the S.C.02-type misalignment symptom. It belongs to the Strategy Execution alignment perspective. Containing EA model is AF.01 Driver/Goal/Objective Catalogue. There are other necessary sources for investigating this symptom.

Table 39. Analysis of EA-Scope Applicability for Misalignment Symptom S.01

Aspect	Misalignment Symptom
Code	S.01
Symptom Category	S.C.02
Alignment Perspective	P.01 Strategy Execution perspective
Alignment Type	C.01 Matching of Business Strategy and Business Structure domains
Symptom Definition	*Undefined organisational mission, strategy, and goals*
Literature Reference	Carvalho and Sousa, 2008
Sign, Presence	Lack of model presence for organisational mission, strategy, and goals
Occurrence, Presence in EA Model	Lack of model presence for organisational mission, strategy, and goals
Containing EA Model	AF.01 Driver/Goal/ Objective Catalogue
Occurrence on Model Entity Level	Missing elements and connections for mission, strategy and goal representation
Other Necessary Sources for Investigation	Up to date description about organisational mission, organisational strategy, goal hierarchy

In *Table 40* misalignment symptom S.02 Undefined business process goals, business process owners will be subject to the analysis of EA-scope applicability. The S.C.01-type misalignment symptom belongs to the Strategy Execution alignment perspective. Containing EA models are AF.01 Driver/Goal/Objective Catalogue, AF.02 Role Catalogue, and AF.09 Business Use-Case Diagram. Although it is an S.C.01-type symptom, there are also other necessary sources for investigating this symptom.

Table 40. Analysis of EA-Scope Applicability for Misalignment Symptom S.02

Aspect	Misalignment Symptom
Code	S.02
Symptom Category	S.C.01
Alignment Perspective	P.01 Strategy Execution perspective
Alignment Type	C.01 Matching of Business Strategy and Business Structure domains
Symptom Definition	*Undefined business process goals, business process owners*
Literature Reference	Carvalho and Sousa, 2008
Sign, Presence	Lack of model presence for business process 1) goals and 2) owners

(Continues)

Table 40. *(Continued)*

Aspect	Misalignment Symptom
Occurrence, Presence in EA Model	Lack of model presence for 1) business process goals, 2) business process owners
Containing EA Model	AF.01 Driver/Goal/Objective Catalogue AF.02 Role Catalogue AF.09 Business Use-Case Diagram
Occurrence on Model Entity Level	Missing elements and connections for business process goal and business process owner representation
Other Necessary Sources for Investigation	Up to date description about business process goals and business process owners

Misalignment symptom S.05 Undefined or multiple hierarchy or lines of reporting will be subject to the analysis of EA-scope applicability in *Table 41*. The S.C.01-type misalignment symptom belongs to the Competitive Potential alignment perspective. Containing EA models are AF.02 Role Catalogue, AF.09 Business Use-Case Diagram and AF.10 Organisational Decomposition Diagram. Although it is an S.C.01-type symptom, there are also other necessary sources for investigating this symptom.

Table 41. Analysis of EA-Scope Applicability for Misalignment Symptom S.05

Aspect	Misalignment Symptom
Code	S.05
Symptom Category	S.C.01
Alignment Perspective	P.03 Competitive Potential perspective
Alignment Type	C.01 Matching of Business Strategy and Business Structure domains
Symptom Definition	*Undefined or multiple hierarchy or lines of reporting*
Literature Reference	Carvalho and Sousa, 2008
Sign, Presence	Malfunctioning lines of reporting
Occurrence, Presence in EA Model	Either undefined or multiple hierarchy or lines of reporting
Containing EA Model	AF.02 Role Catalogue AF.09 Business Use-Case Diagram AF.10 Organisational Decomposition Diagram
Occurrence on Model Entity Level	Missing or multiple connections between business roles for reporting line representation
Other Necessary Sources for Investigation	Up to date description about lines of reporting

In *Table 42* misalignment symptom S.07 Business process task supported by more than one application will be subject to the analysis of EA-scope applicability. The S.C.01-type misalignment symptom belongs to the Strategy Execution alignment perspective. Containing EA models are AF.15 Application Portfolio Catalogue and AF.16 Application/Function Matrix. Although it is an S.C.01-type symptom, there are also other necessary sources for investigating this symptom.

Table 42. Analysis of EA-Scope Applicability for Misalignment Symptom S.07

Aspect	Misalignment Symptom
Code	S.07
Symptom Category	S.C.01
Alignment Perspective	P.01 Strategy Execution perspective
Alignment Type	C.02 Matching of Business Structure and IT Structure domains
Symptom Definition	*Business process task supported by more than one application*
Literature Reference	Sousa et al., 2005
Sign, Presence	Business process tasks are supported by more than one supportive application functions in a business process model
Occurrence, Presence in EA Model	Sum of supportive application functions exceeds 1 per business process tasks
Containing EA Model	AF.15 Application Portfolio Catalogue AF.16 Application/ Function Matrix
Occurrence on Model Entity Level	More than 1 application function is connected to business process tasks
Other Necessary Sources for Investigation	None

Subsequently, misalignment symptom S.16 Out of date technological infrastructure will be subject to the analysis of EA-scope applicability. *Table 43* contains the analysis details of the S.C.01-type misalignment symptom. It belongs to the Service Level alignment perspective. Containing EA models are AF.22 Technology Portfolio Catalogue, AF.24 Platform Decomposition Diagram, and AF.25 Processing Diagram. Although it is an S.C.01-type symptom, there are also other necessary sources for investigating this symptom.

Table 43. Analysis of EA-Scope Applicability for Misalignment Symptom S.16

Aspect	Misalignment Symptom
Code	S.16
Symptom Category	S.C.01
Alignment Perspective	P.04 Service Level perspective
Alignment Type	C.04 Matching of IT Strategy and IT Structure domains
Symptom Definition	*Out of date technological infrastructure*
Literature Reference	Carvalho and Sousa, 2008
Sign, Presence	There are out of date infrastructure elements in models in question
Occurrence, Presence in EA Model	There is a catalogue on up to date technological elements. EA models may contain out of date technological infrastructure elements
Containing EA Model	AF.22 Technology Portfolio Catalogue AF.24 Platform Decomposition Diagram AF.25 Processing Diagram
Occurrence on Model Entity Level	Technological infrastructure elements are found in EA models which are not listed in the up to date technological element catalogue
Other Necessary Sources for Investigation	Catalogue of up to date technological elements

Misalignment symptom S.17 Technological heterogeneity will be subject to the analysis of EA-scope applicability in *Table 44*. The S.C.02-type misalignment symptom belongs to the Service

Level alignment perspective. Containing EA model is AF.24 Platform Decomposition Diagram. There are other necessary sources for investigating this symptom.

Table 44. Analysis of EA-Scope Applicability for Misalignment Symptom S.17

Aspect	Misalignment Symptom
Code	S.17
Symptom Category	S.C.02
Alignment Perspective	P.04 Service Level perspective
Alignment Type	C.04 Matching of IT Strategy and IT Structure domains
Symptom Definition	*Technological heterogeneity*
Literature Reference	Carvalho and Sousa, 2008
Sign, Presence	Heterogeneous infrastructure portfolio supporting applications and – indirectly – process realisation
Occurrence, Presence in EA Model	Several different platforms for application support
Containing EA Model	AF.24 Platform Decomposition Diagram
Occurrence on Model Entity Level	Business services, processes and underlying application components supported by several platforms
Other Necessary Sources for Investigation	Further data on IT infrastructure (CMDB)

In *Table 45* misalignment symptom S.18 Incompatible platforms or technologies will be subject to the analysis of EA-scope applicability. The S.C.01-type misalignment symptom belongs to the Service Level alignment perspective. Containing EA models are AF.22 Technology Portfolio Catalogue, AF.23 Application/Technology Matrix and AF.24 Platform Decomposition Diagram. Although it is an S.C.01-type symptom, there are also other necessary sources for investigating this symptom.

Table 45. Analysis of EA-Scope Applicability for Misalignment Symptom S.18

Aspect	Misalignment Symptom
Code	S.18
Symptom Category	S.C.01
Alignment Perspective	P.04 Service Level perspective
Alignment Type	C.04 Matching of IT Strategy and IT Structure domains
Symptom Definition	*Incompatible platforms or technologies*
Literature Reference	Carvalho and Sousa, 2008
Sign, Presence	There are incompatible technological infrastructure elements in corresponding model variants
Occurrence, Presence in EA Model	There is a list of compatible hardware elements. EA models may contain incompatible hardware elements compared to the list
Containing EA Model	AF.22 Technology Portfolio Catalogue AF.23 Application/Technology Matrix AF.24 Platform Decomposition Diagram
Occurrence on Model Entity Level	Hardware elements are found in EA models which are not listed in the compatible hardware element catalogue
Other Necessary Sources for Investigation	Catalogue of compatible hardware elements

Misalignment symptom S.32 Lack of data ownership will be subject to the analysis of EA-scope applicability in *Table 46*. The S.C.01-type misalignment symptom belongs to the Service Level alignment perspective. Containing EA model is AF.12 Data Entity/Data Component Catalogue. There are no other necessary sources for investigating this symptom.

Table 46. Analysis of EA-Scope Applicability for Misalignment Symptom S.32

Aspect	Misalignment Symptom
Code	S.32
Symptom Category	S.C.01
Alignment Perspective	P.04 Service Level perspective
Alignment Type	C.04 Matching of IT Strategy and IT Structure domains
Symptom Definition	*Lack of data ownership*
Literature Reference	Carvalho and Sousa, 2008
Sign, Presence	Lack of model presence for data ownership in corresponding models
Occurrence, Presence in EA Model	Responsible data owner is not set in data entity models
Containing EA Model	AF.12 Data Entity/Data Component Catalogue
Occurrence on Model Entity Level	Lack of responsible person attribute in data entity models
Other Necessary Sources for Investigation	None

Subsequently, misalignment symptom S.39 Lack of application interfaces will be subject to the analysis of EA-scope applicability in *Table 47*. The S.C.02-type misalignment symptom belongs to the Service Level alignment perspective. Containing EA model is AF.17 Application Interaction Matrix. There are other necessary sources for investigating this symptom.

Table 47. Analysis of EA-Scope Applicability for Misalignment Symptom S.39

Aspect	Misalignment Symptom
Code	S.39
Symptom Category	S.C.02
Alignment Perspective	P.04 Service Level perspective
Alignment Type	C.04 Matching of IT Strategy and IT Structure domains
Symptom Definition	*Lack of application interfaces*
Literature Reference	Carvalho and Sousa, 2008
Sign, Presence	Lack of model presence for application interfaces
Occurrence, Presence in EA Model	There are existing application interfaces that are not marked in the interface models
Containing EA Model	AF.17 Application Interaction Matrix
Occurrence on Model Entity Level	Missing interface elements and optionally data flow indication between two applications that have interactions
Other Necessary Sources for Investigation	Interface models for all existing application interactions

Finally, misalignment symptom S.52 Not all data entity attributes are read at least by one process will be subject to the analysis of EA-scope applicability in *Table 48*. The S.C.01-type misalignment symptom belongs to the Strategy Execution alignment perspective. Containing EA models are

AF.11 Process Flow Diagram, AF.12 Data Entity/Data Component Catalogue, and AF.13 Data Entity/Business Function Matrix. There are no other necessary sources for investigating this symptom.

Table 48. Analysis of EA-Scope Applicability for Misalignment Symptom S.52

Aspect	Misalignment Symptom
Code	S.52
Symptom Category	S.C.01
Alignment Perspective	P.01 Strategy Execution perspective
Alignment Type	C.02 Matching of Business Structure and IT Structure domains
Symptom Definition	*Not all data entity attributes are read at least by one process*
Literature Reference	Pereira and Sousa, 2005
Sign, Presence	There are data entities that are not used by any business process
Occurrence, Presence in EA Model	By scanning data usage in business process models, there are data entities that are not used by any business process tasks
Containing EA Model	AF.11 Process Flow Diagram AF.12 Data Entity/Data Component Catalogue AF.13 Data Entity/Business Function Matrix
Occurrence on Model Entity Level	There are data entities from the data entity catalogue that are not present on any business process model
Other Necessary Sources for Investigation	None

In the following parts of the section misalignment symptoms under the category of S.C.01 will be further analysed with the previously introduced framework for detecting misalignment symptoms in EA scope (*Table 28*). *Table 49-56* specify the analysis for revealing the symptoms in the EA model structure of the road control initiative. EA models presented in the following analysis stem from the abstract model structure (*Figure 31*). As for the subsequent Schematron queries, *Appendix J* contains information on the basic elements of the language.

Table 49 contains the analysis results for detecting misalignment symptom S.02 in EA scope. Suitable EA analysis to detect the symptom is A.03 Coverage analysis. In detecting misalignment symptom S.02 Undefined business process goals, business process owners, missing elements, and connections are revealed in a process flow diagram.

Table 49. Detection of Misalignment Symptom S.02 in EA Scope

ASPECT	MISALIGNMENT SYMPTOM
CODE	S.02
SYMPTOM DEFINITION	*Undefined business process goals, business process owners*
SUITABLE EA ANALYSIS TO DETECT THE SYMPTOM	A.03 Coverage analysis
OCCURRENCE, PRESENCE IN EA MODEL	Lack of model presence for business process goals or business process owners
CONTAINING EA MODEL	AF.01 Driver/Goal/Objective Catalogue AF.02 Role Catalogue AF.09 Business Use-Case Diagram
OCCURRENCE ON MODEL ENTITY LEVEL	Missing elements and connections for business process goal or business process owner representation
CONTAINING EA MODEL IN ROAD CONTROL MODEL STRUCTURE	Process Flow Diagram
OCCURRENCE, PRESENCE IN EA MODEL OF THE ROAD CONTROL MODEL STRUCTURE	Business process goals or business process owners are not set in the business process models – in the following cells of the table both cases will be detailed
OCCURRENCE ON MODEL ENTITY LEVEL IN ROAD CONTROL MODEL STRUCTURE	Lack of process goal attribute or responsible person attribute in the business process models
OCCURRENCE IN XML-BASED EA MODEL EXPORT	Presence or absence of process goals or responsible person at business process tasks
OCCURRENCE ON MODEL ENTITY LEVEL IN XML EXPORT	Presence or absence of Attribute type: process goal or Attribute type: responsible person at Node type: business process task
XML-BASED QUERY	For every node where node type = business process task: - Check the presence of the attribute where type = process goal OR responsible person - Alert business process task nodes if they lack process goal OR responsible person attribute
QUERY IN SCHEMATRON LANGUAGE	<pattern name="S.02 Undefined business process goals, business process owners"> <rule context="Object Definition[@Node Type='{*business process task*}']"> <assert test="Attribute Definition[@AttributeDefinition.Type= '{*process goal* OR *responsible person*}']"> Alert: S.02. </assert> </rule> </pattern>

Table 50 contains the analysis results for detecting misalignment symptom S.05 in EA scope. Suitable EA analysis to detect the symptom is A.01 Dependency analysis. In detecting misalignment symptom S.05 Undefined or multiple hierarchy or lines of reporting, missing or multiple connections are revealed in an organisation decomposition diagram.

Table 50. Detection of Misalignment Symptom S.05 in EA Scope

ASPECT	MISALIGNMENT SYMPTOM
CODE	S.05
SYMPTOM DEFINITION	*Undefined or multiple hierarchy or lines of reporting*
SUITABLE EA ANALYSIS TO DETECT THE SYMPTOM	A.01 Dependency analysis
OCCURRENCE, PRESENCE IN EA MODEL	Either undefined or multiple hierarchy or lines of reporting
CONTAINING EA MODEL	AF.02 Role Catalogue AF.09 Business Use-Case Diagram AF.10 Organisation Decomposition Diagram
OCCURRENCE ON MODEL ENTITY LEVEL	Missing or multiple connections between business roles for reporting line representation
CONTAINING EA MODEL IN ROAD CONTROL MODEL STRUCTURE	Organisation Decomposition Diagram
OCCURRENCE, PRESENCE IN EA MODEL OF THE ROAD CONTROL MODEL STRUCTURE	Either undefined or multiple hierarchy or lines of reporting – in the following cells of the table the *multiple case* will be detailed
OCCURRENCE ON MODEL ENTITY LEVEL IN ROAD CONTROL MODEL STRUCTURE	Multiple connections between business collaboration entities for reporting line representation
OCCURRENCE IN XML-BASED EA MODEL EXPORT	Multiple relations between Node type: Business collaboration and Node type: Business collaboration in terms of lines of reporting
OCCURRENCE ON MODEL ENTITY LEVEL IN XML EXPORT	Number of relations where relation attribute type: has superior between Node type: Business collaboration and Node type: Business collaboration
XML-BASED QUERY	For every node where node type = business collaboration: - Check whether the element (node type = business collaboration) has a valid subordinated element (node type = business collaboration) (S.05/A) - Check whether node relation reference to superior where relation attribute type = has superior equals with another node relation reference to superior where node type = has superior (S.05/B) - Report business collaboration nodes with valid subordinated business collaboration node (S.05/A) - Alert business collaboration nodes where the same node relation reference is given to superior (S.05/B)

(Continues)

Table 50. *(Continued)*

Aspect	Misalignment Symptom
Query in Schematron Language	<pattern name="S.05/A Undefined or multiple hierarchy or lines of reporting"> <rule context="Object Definition[@Node Type='{*business collaboration*}']"> <report test="@ObjectDefinition.ID=following-sibling:: [@Node Type='{*business collaboration*}']/Connection Definition[@Connection Definition.Type='{*has superior*}']/@ToObjectDefinition.IdRef or @ObjectDefinition.ID=preceding-sibling::ObjectDefinition[@Type Num='{*business collaboration*}']/Connection Definition[@Connection Definition.Type='{*has superior*}']/@ToObjectDefinition.IdRef"> Alert: S.05/A </report> </rule> </pattern> <pattern name="S.05/B Undefined or multiple hierarchy or lines of reporting"> <rule context="Object Definition[@Node Type='{*business collaboration*}']"> <report test="Connection Definition[@ToObjectDefinition.IdRef= parent::Object Definition/following-sibling::Object Definition[@Node Type='{*business collaboration*}']/Connection Definition[@Connection Definition.Type='{*has superior*}']/@ToObjectDefinition.IdRef] or Connection Definition[@ToObjectDefinition.IdRef= parent::Object Definition/predecing-sibling::Object Definition[@Node Type='{*business collaboration*}']/Connection Definition[@Connection Definition.Type='{*has superior*} ']/@ToObjectDefinition.IdRef] "> Alert: S.05/B </report> </rule> </pattern>

Operation results for detecting misalignment symptom S.07 in the necessary EA models will be summarised in the following subsection. Firstly, an excerpt will be given to demonstrate the applicability of dependency analysis for misalignment symptom S.07. Secondly, the previously introduced detection technique will be validated against misalignment symptom S.07.

First, an excerpt is given from dependency analysis between groups of business process tasks and supportive applications (*Table 51*). In this illustrative example, a fragment of business process tasks from Road Control and Dispatcher Service are matched with application components that play an essential role in business process realisation. The result of the dependency analysis appears in a matrix form. Rows represent groups of business process tasks, while applications are illustrated in columns. Dependency relations are displayed in cells: groups of business process tasks depend on an application during the sequence flow of the business process.

The example illustrates misalignment symptom S.07 Business process task supported by more than one application, which is a typical symptom of P.01 Strategy Execution perspective, C.02 Matching of Business Structure and IT Structure domains perspective component. According to previously introduced matches of containing EA models and suitable EA analysis types, the artefact that may contain this symptom is e.g. AF.16 Application/ Function Matrix. The suitable analysis that is able to detect the symptom in the artefact is e.g. A.01 Dependency analysis. As we can see from the table, three groups of business process tasks fulfill the requirements of this misalignment symptom: Administrating road control tasks, Forwarding information and Road control plan preparation. These business process task groups are supported by more than one application during process execution.

Table 51. Excerpt from a Dependency Analysis between Groups of Business Process Tasks and Applications

Application / Groups of Business Process Tasks	EASYWAY	INFOPULT	ERP	KOMVIR	SPREADSHEET	SHAREPOINT	OKA2000
Administrating road control tasks			●		●		
Forwarding information	●	●					
Information recording and consolidation				●			
Receiving notification						●	
Road control plan preparation					●	●	●
Road control plan verification					●		

After briefly summarising the applicability of dependency analysis for misalignment symptom detection, the section continues with the specific analysis results of misalignment symptom S.07. *Table 52* contains the analysis results for detecting misalignment symptom S.07 in EA scope. Suitable EA analysis to detect the symptom is A.01 Dependency analysis. In detecting misalignment symptom S.07 Business process task supported by more than one application, the cardinality of applications connected to business process tasks are counted in a process/application realisation diagram.

In *Table 53* the analysis results are presented for detecting misalignment symptom S.16 in EA scope. Suitable EA analyses to detect the symptom are A.03 Coverage analysis, A.06 Enterprise interoperability assessment, and A.08 Heterogeneity analysis. In detecting misalignment symptom S.16 Out of date technological infrastructure, technological infrastructure elements are revealed in EA models which are not listed in the catalogue of up to date technological elements.

Subsequently, *Table 54* contains the analysis results for detecting misalignment symptom S.18 in EA scope. Suitable EA analyses to detect the symptom are A.04 Interface analysis and A.06 Enterprise interoperability assessment. In detecting misalignment symptom S.18 Incompatible platforms or technologies, incompatible hardware elements are revealed compared to the catalogue of supported hardware elements.

In *Table 55* the analysis results are presented for detecting misalignment symptom S.32 in EA scope. Suitable EA analysis to detect the symptom is A.03 Coverage analysis. In detecting misalignment symptom S.32 Lack of data ownership, missing attributes are revealed in data entity models.

Table 52. Detection of Misalignment Symptom S.07 in EA Scope

Aspect	Misalignment Symptom
Code	S.07
Symptom Definition	*Business process task supported by more than one application*
Suitable EA Analysis to detect the symptom	A.01 Dependency analysis
Occurrence, Presence in EA Model	Sum of applications exceeds 1 per business process tasks
Containing EA Model	AF.15 Application Portfolio Catalogue AF.16 Application/ Function Matrix
Occurrence on Model Entity Level	Application functions connected to business process tasks
Containing EA Model in Road Control Model Structure	Process/Application Realisation Diagram
Occurrence, Presence in EA Model of the Road Control Model Structure	Sum of supportive applications exceeds 1 per business process tasks in a process flow
Occurrence on Model Entity Level in Road Control Model Structure	Application functions connected to business process tasks
Occurrence in XML-based EA Model Export	Relations between Node type: Business process task and Node type: Application function
Occurrence on Model Entity Level in XML Export	Number of relations between Node type: Business process task and Node type: Application function per Node type: Business process task
XML-based Query	For every node where node type = business process task: - Numerate node relations where node type = application function - Alert business process task nodes with >1 application function connections
Query in Schematron Language	<pattern name="S.07. Business process task supported by more than one application"> <rule context="Object Definition[@Node Type='{*business process task*}']"> <report test="count(Connection Definition [@ToObjectDefinition.IdRef=parent::Object Definition/following-sibling::Object Definition[@Node Type='{*application function*}'] /@ObjectDefinition.ID or @ToObject Definition.IdRef=parent::Object Definition/preceding-sibling::Object Definition[@Node Type= '{*application function*}']/ @ObjectDefinition.ID])>1"> Alert: S.07. </report> </rule> </pattern>

Table 53. Detection of Misalignment Symptom S.16 in EA Scope

ASPECT	MISALIGNMENT SYMPTOM
CODE	S.16
SYMPTOM DEFINITION	*Out of date technological infrastructure*
SUITABLE EA ANALYSIS TO DETECT THE SYMPTOM	A.03 Coverage analysis A.06 Enterprise interoperability assessment A.08 Heterogeneity analysis
OCCURRENCE, PRESENCE IN EA MODEL	There is a catalogue on up to date technological elements. EA models may contain out of date technological infrastructure elements
CONTAINING EA MODEL	AF.22 Technology Portfolio Catalogue AF.24 Platform Decomposition Diagram AF.25 Processing Diagram
OCCURRENCE ON MODEL ENTITY LEVEL	Technological infrastructure elements are found in EA models which are not listed in the up to date technological element catalogue
CONTAINING EA MODEL IN ROAD CONTROL MODEL STRUCTURE	Process/Application Realisation Diagram Application/Technology Matrix Technological Element Catalogue
OCCURRENCE, PRESENCE IN EA MODEL OF THE ROAD CONTROL MODEL STRUCTURE	EA models on infrastructure usage contain out of date technological infrastructure elements, i.e. they are not listed in the technological element catalogue on up to date technological elements
OCCURRENCE ON MODEL ENTITY LEVEL IN ROAD CONTROL MODEL STRUCTURE	Technological infrastructure elements are found in EA models on infrastructure usage (attribute: version of the technological element) which are not listed in the up to date technological element catalogue (attribute: version of the technological element)
OCCURRENCE IN XML-BASED EA MODEL EXPORT	Comparison of infrastructure usage model and technological element catalogue in terms of technological element versions
OCCURRENCE ON MODEL ENTITY LEVEL IN XML EXPORT	Comparison of attribute versions between Node type: application system in the infrastructure usage model and Node type: application system in the technological element catalogue
XML-BASED QUERY	For every node where node type = application system: - Compare the attribute version with the supported versions from technological element catalogue - Alert application system nodes if they use non-supported (i.e. out of date) technological elements
QUERY IN SCHEMATRON LANGUAGE	<pattern name="S.16. Out of date technological infrastructure "> <rule context="Object Definition[@Node Type='{*application system*}']"> <assert test="Attribute Definition[@AttributeDefinition.Type='{*attribute version*}']//PlainText[@TextValue=document ('technological element catalogue.xml')//Object Definition[@Node Type='{*application system*}']//Attribute Definition[@Attribute Definition.Type='{*attribute version*}']//PlainText//@TextValue]"> Alert: S.16 </assert> </rule> </pattern>

Table 54. Detection of Misalignment Symptom S.18 in EA Scope

Aspect	Misalignment Symptom
Code	S.18
Symptom Definition	*Incompatible platforms or technologies*
Suitable EA Analysis to detect the symptom	A.04 Interface analysis A.06 Enterprise interoperability assessment
Occurrence, Presence in EA Model	There is a list of compatible hardware elements. EA models may contain incompatible hardware elements compared to the list
Containing EA Model	AF.22 Technology Portfolio Catalogue AF.23 Application/Technology Matrix AF.24 Platform Decomposition Diagram
Occurrence on Model Entity Level	EA models on infrastructure usage contain hardware elements that are not listed in the compatible technological element catalogue
Containing EA Model in Road Control Model Structure	Process/Application Realisation Diagram Application/Technology Matrix Technological Element Catalogue
Occurrence, Presence in EA Model of the Road Control Model Structure	Hardware elements are found in EA models on infrastructure usage which are not listed in the compatible technological element catalogue – incompatible hardware elements are found in EA models compared to the list of compatible technological elements
Occurrence on Model Entity Level in Road Control Model Structure	Hardware elements are found in EA models on infrastructure usage which are not listed in the compatible technological element catalogue
Occurrence in XML-based EA Model Export	Comparison of infrastructure usage model and technological element catalogue in terms of hardware elements
Occurrence on Model Entity Level in XML Export	Comparison of elements between Node type: hardware component in the infrastructure usage model and Node type: hardware component in the technological element catalogue
XML-based Query	For every node where node type = hardware component: - Compare the attribute names with the hardware component attribute names from technological element catalogue - Alert hardware component nodes if they use non-supported (i.e. incompatible) hardware components
Query in Schematron Language	<pattern name="S.18. Incompatible platforms or technologies"> <rule context="Object Definition[@Node Type='{*hardware component*}']"> <assert test="Attribute Definition[@AttributeDefinition.Type= '{*attribute name*}']//PlainText [@TextValue=document('technological element catalogue.xml') //Object Definition[@Node Type='{*hardware component*}'] //Attribute Definition[@AttributeDefinition.Type= '{*attribute name*}'] //PlainText/@TextValue]"> Alert: S.18 </assert> </rule> </pattern>

Table 55. Detection of Misalignment Symptom S.32 in EA Scope

Aspect	Misalignment Symptom
Code	S.32
Symptom Definition	*Lack of data ownership*
Suitable EA Analysis to detect the symptom	A.03 Coverage analysis
Occurrence, Presence in EA Model	Responsible data owner is not set in data entity models
Containing EA Model	AF.12 Data Entity/Data Component Catalogue
Occurrence on Model Entity Level	Lack of responsible person attribute in data entity models
Containing EA Model in Road Control Model Structure	Data Entity/Data Component Catalogue
Occurrence, Presence in EA Model of the Road Control Model Structure	Responsible data owner is not set in data entity models
Occurrence on Model Entity Level in Road Control Model Structure	Lack of responsible person attribute in data entity models
Occurrence in XML-based EA Model Export	Presence or absence of responsible person at data entities
Occurrence on Model Entity Level in XML Export	Presence or absence of Attribute type: responsible person at Node type: data entity
XML-based Query	For every node where node type = data entity: - Check the presence of the attribute where type = responsible person - Alert data entity nodes if they lack responsible person attribute
Query in Schematron Language	<pattern name="S.32 Lack of data ownership"> <rule context="Object Definition[@Node Type='{*data entity*}']"> <assert test="Attribute Definition[@AttributeDefinition.Type= '{*responsible person*}']"> Alert: S.32 </assert> </rule> </pattern>

Finally, *Table 56* contains the analysis results for detecting misalignment symptom S.52 in EA scope. Suitable EA analyses to detect the symptom are A.01 Dependency analysis and A.03 Coverage analysis. In detecting misalignment symptom S.52 Not all data entity attributes are read at least by one process, unused data entities are revealed in a process flow diagram.

The subsection has introduced the process of misalignment symptom analysis in the road control initiative. Perceived misalignment symptoms were categorised using the previously introduced S.C.01-S.C.03 categorisation. S.C.01 and S.C.02-type symptoms were analysed according to the proposed research framework. The frameworks of *Table 27* and *Table 28* were operated with perceived misalignment symptom records.

Table 56. Detection of Misalignment Symptom S.52 in EA Scope

Aspect	Misalignment Symptom
Code	S.52
Symptom Definition	*Not all data entities attributes are read at least by one process*
Suitable EA Analysis to detect the symptom	A.01 Dependency analysis A.03 Coverage analysis
Occurrence, Presence in EA Model	By scanning data usage in business process models, there are data entities that are not used by any business process task
Containing EA Model	AF.11 Process Flow Diagram AF.12 Data Entity/Data Component Catalogue AF.13 Data Entity/Business Function Matrix
Occurrence on Model Entity Level	There are data entities from the data entity catalogue that are not present on any business process model
Containing EA Model in Road Control Model Structure	Data Entity/Data Component Catalogue Process Flow Diagram
Occurrence, Presence in EA Model of the Road Control Model Structure	By scanning data usage in business process models, there are data entities that are not used by any business process task
Occurrence on Model Entity Level in Road Control Model Structure	There are data entities from the data entity catalogue that are not present on any business process model
Occurrence in XML-based EA Model Export	Comparison of business process models and data entity catalogue in terms of data entities
Occurrence on Model Entity Level in XML Export	Comparison of elements between Node type: data entity in the business process model and Node type: data entity in the data entity catalogue
XML-based Query	For every node where node type = data entity: - Compare the attribute names with the data entity attribute names from process flow diagram - Alert data entity nodes if they are not present in the process flow
Query in Schematron Language	<pattern name="S.52 Not all data entities attributes are read at least by one process"> <rule context="Object Definition[@Node Type='{*data entity*}']"> <assert test="Attribute Definition[@AttributeDefinition.Type= '{*attribute name*}']//PlainText[@TextValue=document ('process flow diagram.xml')//Object Definition[@Node Type='{*data entity*}'] //Attribute Definition[@AttributeDefinition.Type='{*attribute name*}'] //PlainText//@TextValue]"> Alert: S.52 </assert> </rule> </pattern>

This section dealt with misalignment symptom analysis by operating the frameworks of *Table 27* and *Table 28*. The section ends with the definition of general queries for misalignment symptom detection which will be detailed in the following section.

4.6 Misalignment Symptom Detection

This section details the process of misalignment symptom detection for the previously analysed misalignment symptoms. First, EA models from the road control initiative will be added to every misalignment symptom under detection. These EA models will be subjected to symptom detection in the following parts of the section. The summary of model usage will be followed by some emphatic EA model representations both with graphical and XML views. Subsequently, the previously introduced general queries will be customised to the actual EA models in the road management initiative. The section ends with some exemplary processing outputs on misalignment symptom detection.

The section commences with an analysis of model usage for symptom detection. The previously introduced general Schematron queries will be processed for every suitable EA model within the road management initiative. *Table 57* lists the relevant road control models for every misalignment symptom under detection. As can be seen, most of the symptoms use several EA models for detection but there are also examples for sole EA model symptom detection (e.g. S.05). In the former case there are three alternatives for multi-model usage: 1) Different model variants are analysed in the query (e.g. S.02, S.07, S.32). This means that the symptom is processed in more or every state of the project. 2) Two or more EA models are used in the queries for mostly comparative queries (e.g. S.16, S.18, S.52). In this alternative, the queries can be later analysed according to the changes in model variants over time (e.g. S.18 for incompatibility checking). 3) Both different model variants and two or more distinctive model types are used in the queries. Similar to the previous alternative, changes in model variants can be analysed over time as well.

Table 57. Relevant EA Models for Misalignment Symptom Detection

CODE	MISALIGNMENT SYMPTOM	EA MODEL
S.02	Undefined business process goals, business process owners	▪ Road Control Process 1.0 ▪ Road Control Process 2.0
S.05	Undefined or multiple hierarchy or lines of reporting	▪ Road Control Roles and Reporting Lines
S.07	Business process task supported by more than one application	▪ Road Control System 1.0 with Services ▪ Road Control System 2.0 with Services
S.16	Out of date technological infrastructure	▪ Technological Software Components ▪ Road Control System 1.0 Infrastructure Usage Model ▪ Road Control System 2.0 Infrastructure Usage Model
S.18	Incompatible platforms or technologies	▪ Technological Hardware Components ▪ Road Control System 1.0 Infrastructure Usage Model ▪ Road Control System 2.0 Infrastructure Usage Model
S.32	Lack of data ownership	▪ Road Control Data Model OV ▪ Road Control Data Model 1.0 ▪ Road Control Data Model 2.0
S.52	Not all data entities are read at least by one process	▪ Road Control Process 1.0 ▪ Road Control Process 2.0 ▪ Road Control Data Model 1.0 ▪ Road Control Data Model 2.0

Subsequently, exemplary EA models are presented with both graphical and XML view. Model fragments are selected according to the relevance for symptom detection. To support interpretation and readability, *Appendix H* contains the schematic structure of an ARIS XML export (called AML). *Appendix I* contains the document type definition for ARIS exports. To start with, *Figure 34* presents Road Control Process 1.0 model representation for misalignment symptoms S.02 and S.52.

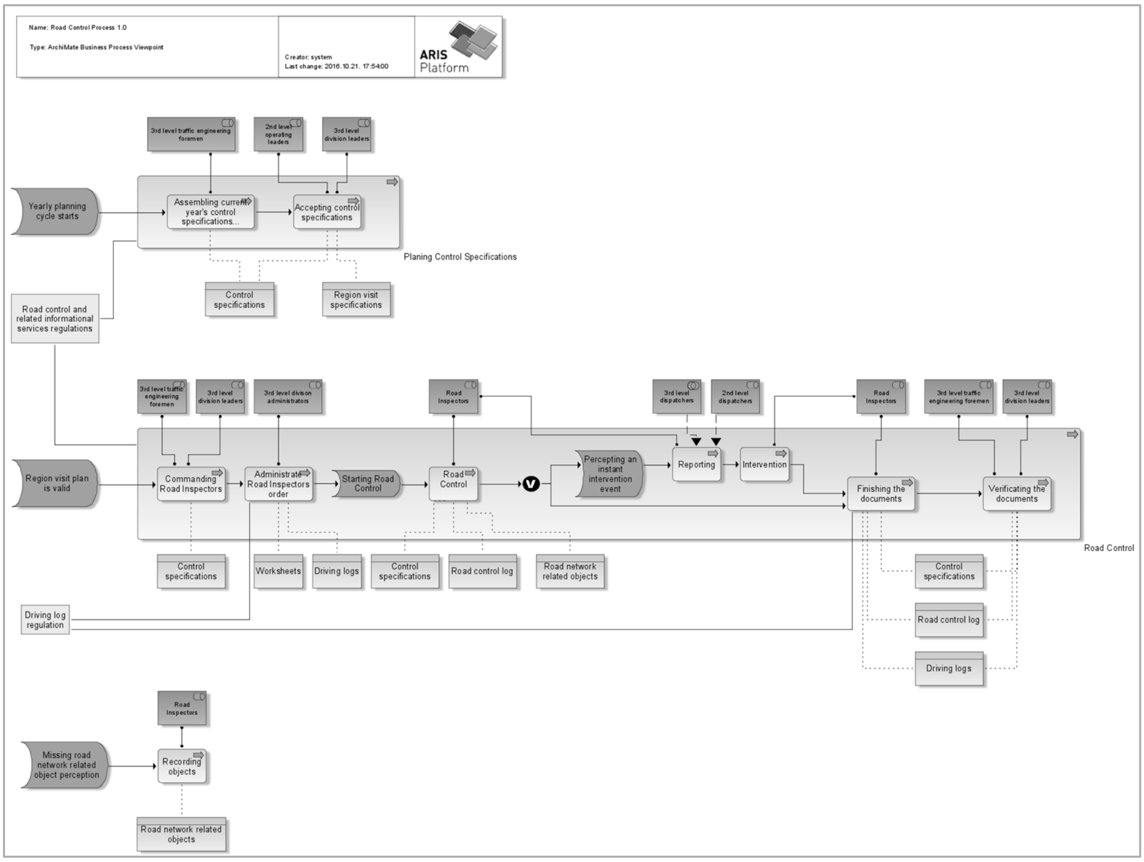


Figure 34. Road Control Process 1.0 Model Representation for Misalignment Symptoms S.02 and S.52

Figure 35 shows an excerpt from Road Control Process 1.0 XML export for the detection of misalignment symptom S.02. The excerpt contains an object definition node from the type of business process task (TypeNum=”OT_FUNC”) with an attribute definition element for business process owner (AttrDef.Type=”AT_PERS_RESP”).

Figure 36 shows an excerpt from Road Control Process 1.0 XML export for the detection of misalignment symptom S.52. The excerpt contains an object definition node from the type of data entity (TypeNum=”OT_CLST”) with an attribute definition element for the name of data entities (AttrDef.Type=”AT_NAME”).

Figure 37 presents Road Control Roles and Reporting Lines model representation for misalignment symptom S.05.

```xml
<ObjDef ObjDef.ID="ObjDef.5V9fxba5k_H-p-L"
    TypeNum="OT_FUNC"
    ToCxnDefs.IdRefs="   CxnDef.-6GlqpAHySru-q-L  "
    SymbolNum="ST_FUNC"
>
    <AttrDef AttrDef.Type="AT_PERS_RESP">
        <AttrValue>
            <StyledElement>
                <Paragraph Alignment="UNDEFINED" Indent="0"/>
                    <StyledElement>
                        <PlainText TextValue="Director of Operations"/>
                    </StyledElement>
            </StyledElement>
        </AttrValue>
    </AttrDef>
    <AttrDef AttrDef.Type="AT_NAME">
        <AttrValue>
            <StyledElement>
                <Paragraph Alignment="UNDEFINED" Indent="0"/>
                    <StyledElement>
                        <PlainText TextValue="Planing Control Specifications"/>
                    </StyledElement>
            </StyledElement>
        </AttrValue>
    </AttrDef>
</ObjDef>
```

Figure 35. Excerpt from Road Control Process 1.0 XML Export for Misalignment Symptom S.02

```xml
<ObjDef ObjDef.ID="ObjDef.5V9fxba5k_H-p-L"
    TypeNum="OT_CLST"
    ToCxnDefs.IdRefs="   CxnDef.-6GlqpAHySru-q-L  "
    SymbolNum="ST_CLST"
>
    <AttrDef AttrDef.Type="AT_PERS_RESP">
        <AttrValue>
            <StyledElement>
                <Paragraph Alignment="UNDEFINED" Indent="0"/>
                    <StyledElement>
                        <PlainText TextValue="Road Inspectors"/>
                    </StyledElement>
            </StyledElement>
        </AttrValue>
    </AttrDef>
    <AttrDef AttrDef.Type="AT_NAME">
        <AttrValue>
            <StyledElement>
                <Paragraph Alignment="UNDEFINED" Indent="0"/>
                    <StyledElement>
                        <PlainText TextValue="Road Control Records"/>
                    </StyledElement>
            </StyledElement>
        </AttrValue>
    </AttrDef>
</ObjDef>
```

Figure 36. Excerpt from Road Control Process 1.0 XML Export for Misalignment Symptom S.52

Figure 38 shows an excerpt from Road Control Roles and Reporting Lines XML export for the detection of misalignment symptom S.05. The excerpt contains an object definition node from the type of business collaboration (TypeNum=”OT_GRP”) with a connection definition element to refer to superior business collaboration object(s) (CxnDef.Type=”CT_IS_SUPERIOR_1”; ToObjDef.IdRef=”ObjDef.SjLr5kDwCy-p-L”).

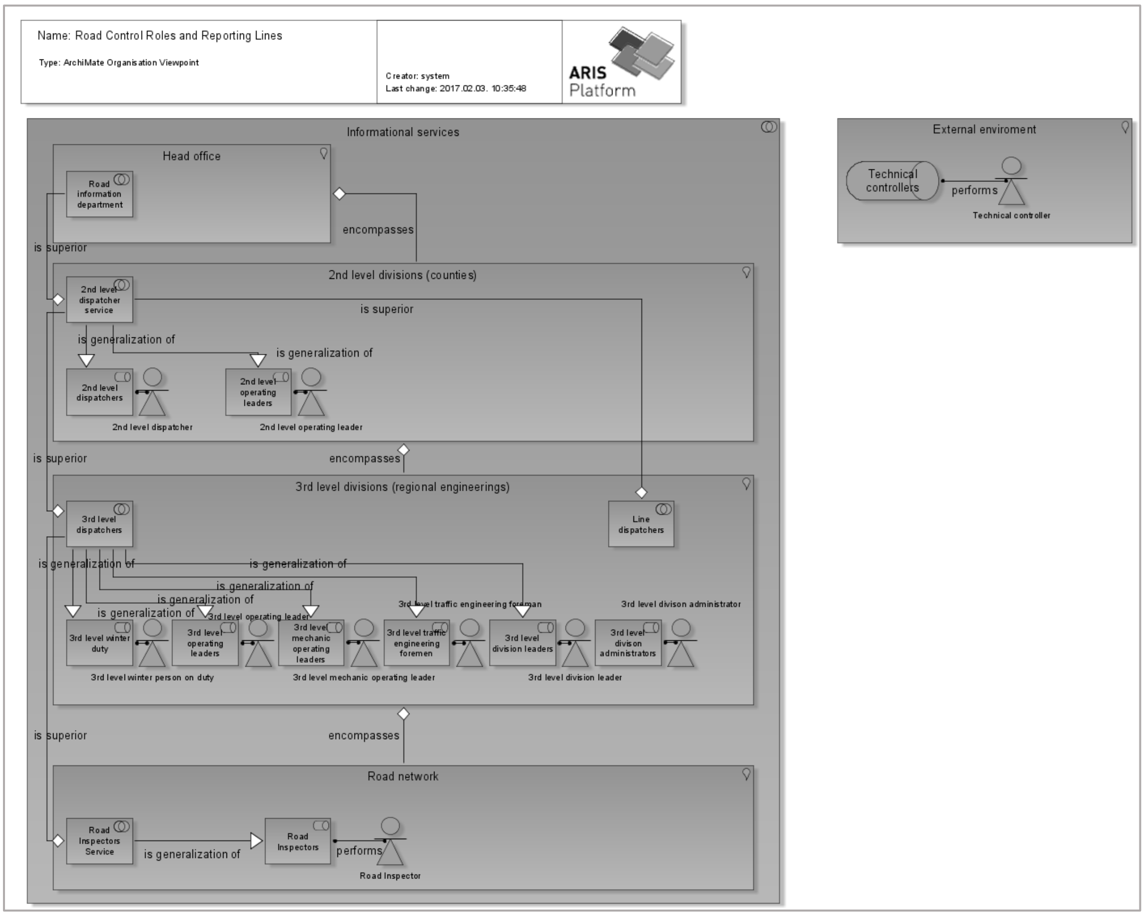


Figure 37. Road Control Roles and Reporting Lines Model Representation for Misalignment Symptom S.05


```
<ObjDef ObjDef.ID="ObjDef.3DPnvfOJVp1-p-L"
    TypeNum="OT GRP"
    SymbolNum="ST_GRP"
>
    <CxnDef CxnDef.ID="CxnDef.-1_Mr4iNvSGa-q-L"
        CxnDef.Type="CT IS SUPERIOR 1"
        ToObjDef.IdRef="ObjDef.SjLr5kDwCy-p-L"
>
    </CxnDef>
</ObjDef>
<ObjDef ObjDef.ID="ObjDef.-3o589IEZQx4-p-L"
    TypeNum="OT_GRP"
    ToCxnDefs.IdRefs="  CxnDef.-7mTn0AY4N0h-q-L"
    SymbolNum="ST_GRP"
>
    <CxnDef CxnDef.ID="CxnDef.-1GVsiFmdTQz-q-L"
        CxnDef.Type="CT_IS_SUPERIOR_1"
        ToObjDef.IdRef="ObjDef.2mrUGnh3kZW-p-L"
>
    </CxnDef>
</ObjDef>
```


Figure 38. Excerpt from Road Control Roles and Reporting Lines XML Export for Misalignment Symptom S.05

Figure 39 presents Road Control System 1.0 with Services model representation for misalignment symptom S.07.

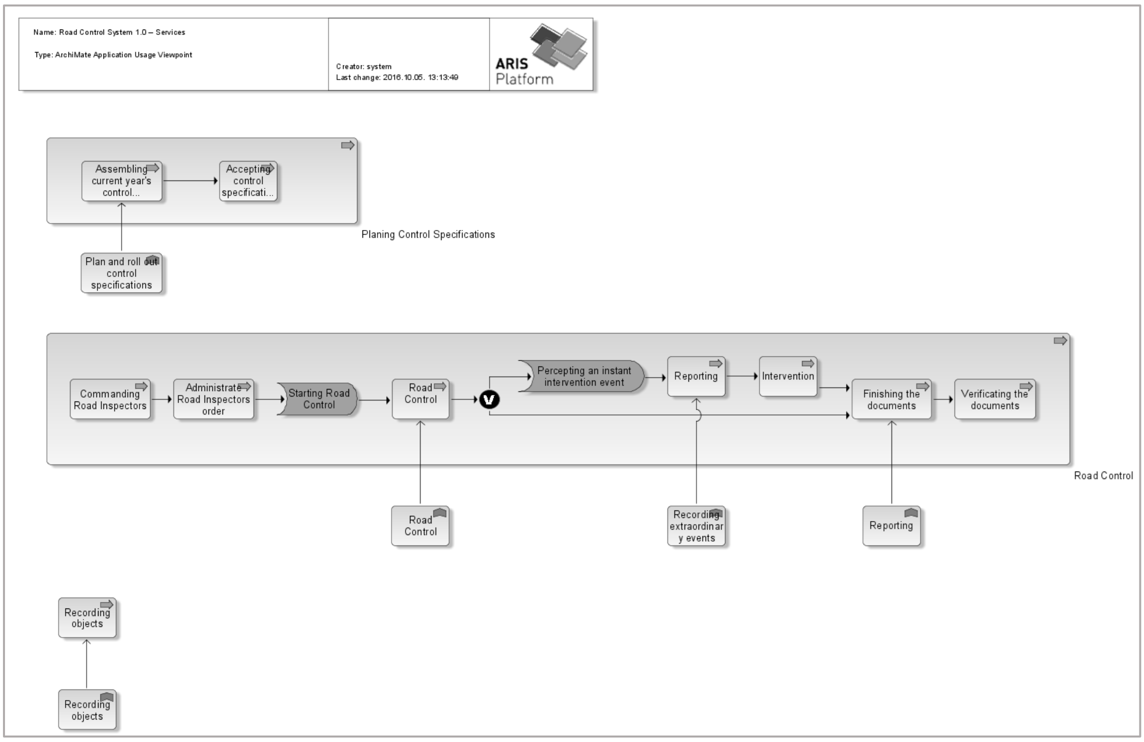


Figure 39. Road Control System 1.0 with Services Model Representation for Misalignment Symptom S.07

Figure 40 shows an excerpt from Road Control System 1.0 with Services XML export for the detection of misalignment symptom S.07. The excerpt contains an object definition node from the type of application (TypeNum="OT_DP_FUNC_TYPE") with a connection definition element and another object definition node from the type of business process task (TypeNum="OT_FUNC") with another connection definition element.


```xml
<ObjDef ObjDef.ID="ObjDef.-1SmTWWBya0A-p-L"
    TypeNum="OT_DP_FUNC_TYPE"
    ToCxnDefs.IdRefs="  CxnDef.5tgaslps0yP-q-L   "
    SymbolNum="ST_DP_FUNC_TYPE"
>
    <CxnDef CxnDef.ID="CxnDef.-1jT7EiCj0y2-q-L"
        CxnDef.Type="CT_ARCHIMATE_ASSOCIATION"
        ToObjDef.IdRef="ObjDef.-6LkEJPMGz33-p-L"
>
    </CxnDef>
</ObjDef>
<ObjDef ObjDef.ID="ObjDef.QK0z2CrIif-p-L"
    TypeNum="OT_FUNC"
    ToCxnDefs.IdRefs="CxnDef.G-LEEK3J7R-q-L CxnDef.-465Ri5VWjA--q-L  "
    SymbolNum="ST_FUNC"
>
    <CxnDef CxnDef.ID="CxnDef.-5aW7JDEk8Lk-q-L"
        CxnDef.Type="CT_IS_PREDEC_OF_1"
        ToObjDef.IdRef="ObjDef.33f6mJ9KoIf-p-L"
>
    </CxnDef>
</ObjDef>
```


Figure 40. Excerpt from Road Control System 1.0 with Services XML Export for Misalignment Symptom S.07

Figure 41 presents Road Control System 1.0 Infrastructure Usage model representation for misalignment symptoms S.16 and S.18. *Figure 42* presents Technological Software Components model representation for misalignment symptom S.16. *Figure 43* presents Technological Hardware Components model representation for misalignment symptom S.18.

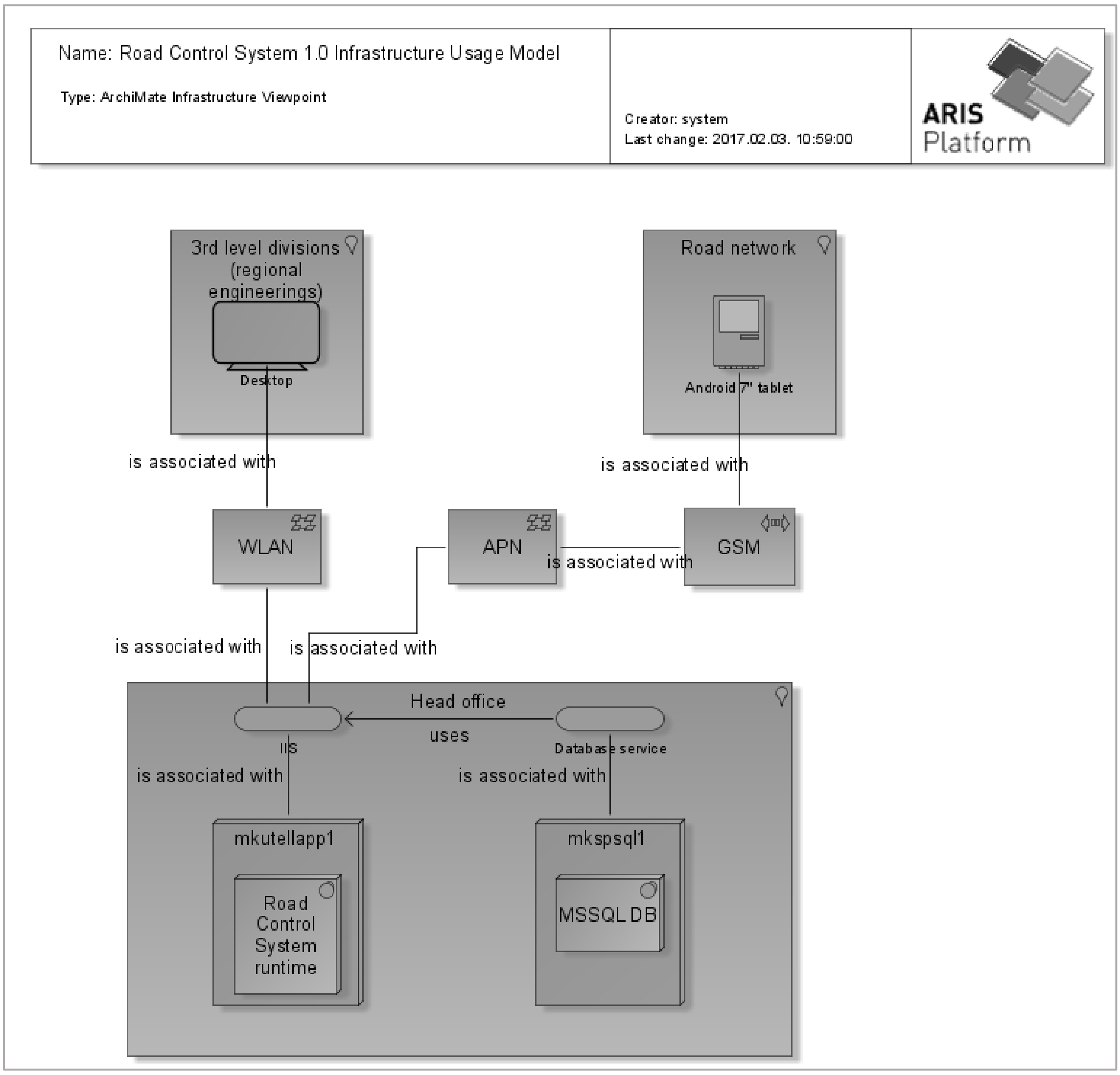


Figure 41. Road Control System 1.0 Infrastructure Usage Model Representation for Misalignment Symptoms S.16 and S.18

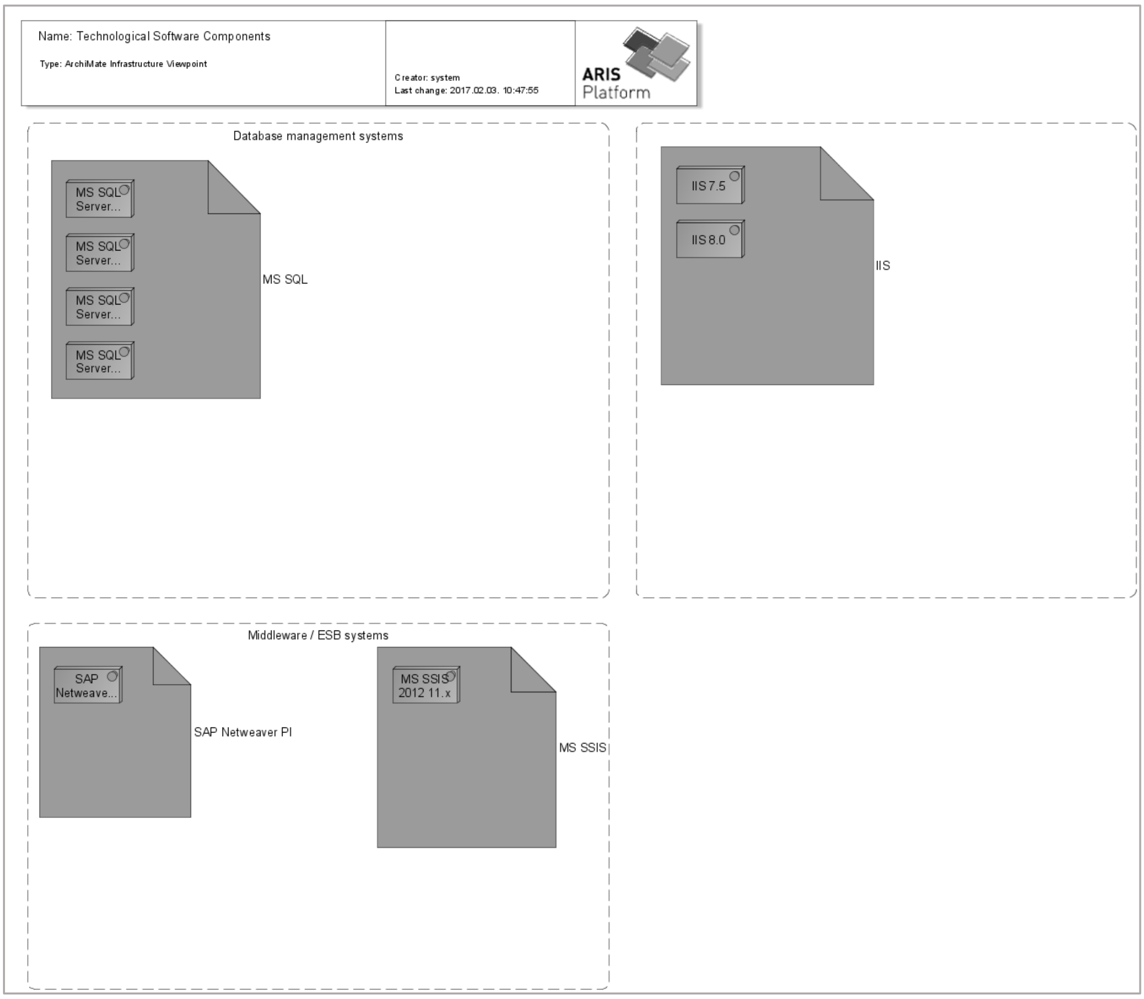


Figure 42. Technological Software Components Model Representation for Misalignment Symptom S.16

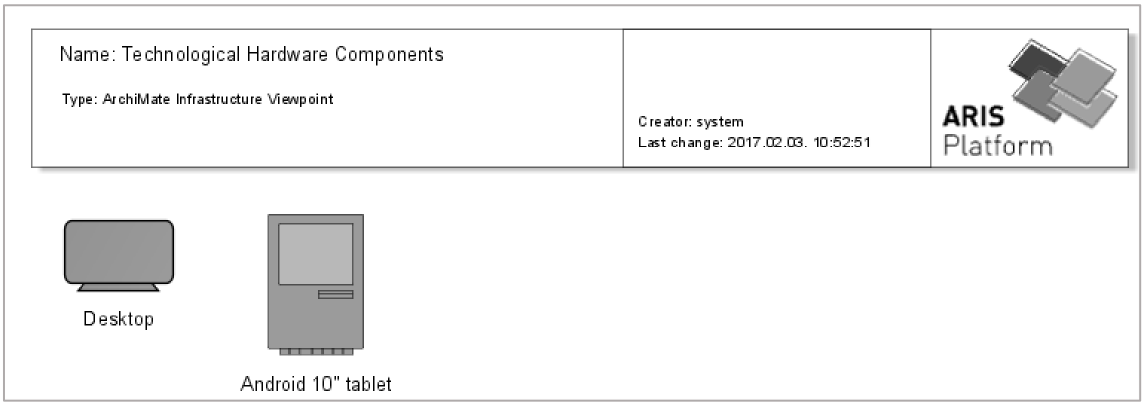


Figure 43. Technological Hardware Components Model Representation for Misalignment Symptom S.18

Figure 44 shows an excerpt from Road Control System 1.0 Infrastructure Usage Model XML export for the detection of misalignment symptom S.16. The excerpt contains an object definition node from the type of application system (TypeNum="OT_APPL_SYS_TYPE") with an attribute definition element for the version of the application system (AttrDef.Type="AT_VERS_REL").

```xml
<ObjDef ObjDef.ID="ObjDef.72XhZmMo-xv-p-L"
    TypeNum="OT_APPL_SYS_TYPE"
    ToCxnDefs.IdRefs="CxnDef.-7ssQP3LqaCX-q-L"
    SymbolNum="ST_APPL_SYS_TYPE"
>
    <AttrDef AttrDef.Type="AT_VERS_REL">
        <AttrValue >
            <StyledElement>
                <Paragraph Alignment="UNDEFINED" Indent="0"/>
                    <StyledElement>
                        <PlainText TextValue="MS SQL Server 2008 R2 10.5x"/>
                    </StyledElement>
            </StyledElement>
        </AttrValue>
    </AttrDef>
    <AttrDef AttrDef.Type="AT_NAME">
        <AttrValue >
            <StyledElement>
                <Paragraph Alignment="UNDEFINED" Indent="0"/>
                    <StyledElement>
                        <PlainText TextValue="MSSQL DB"/>
                    </StyledElement>
            </StyledElement>
        </AttrValue>
    </AttrDef>
</ObjDef>
```

Figure 44. Excerpt from Road Control System 1.0 Infrastructure Usage Model XML Export for Misalignment Symptom S.16

Figure 45 shows an excerpt from Road Control System 1.0 Infrastructure Usage Model XML export for the detection of misalignment symptom S.18. The excerpt contains an object definition node from the type of hardware component (TypeNum="OT_HW_CMP_TYPE") with an attribute definition element for the name of the hardware component (AttrDef.Type="AT_NAME").

```xml
<ObjDef ObjDef.ID="ObjDef.7BU_-Ug-R0u-p-L"
    TypeNum="OT_HW_CMP_TYPE"
    ToCxnDefs.IdRefs="CxnDef.ebPqZ1ksr0-q-L CxnDef.381QN-2EBJ2-q-L"
    SymbolNum="ST_HW_CMP_TYPE"
>
    <AttrDef AttrDef.Type="AT_NAME">
        <AttrValue  >
            <StyledElement>
                <Paragraph Alignment="UNDEFINED" Indent="0"/>
                    <StyledElement>
                        <PlainText TextValue="Android 7&quot; tablet"/>
                    </StyledElement>
            </StyledElement>
        </AttrValue>
    </AttrDef>
</ObjDef>
```

Figure 45. Excerpt from Road Control System 1.0 Infrastructure Usage Model XML Export for Misalignment Symptom S.18

Figure 46 presents Road Control Data Model OV model representation for misalignment symptom S.32.

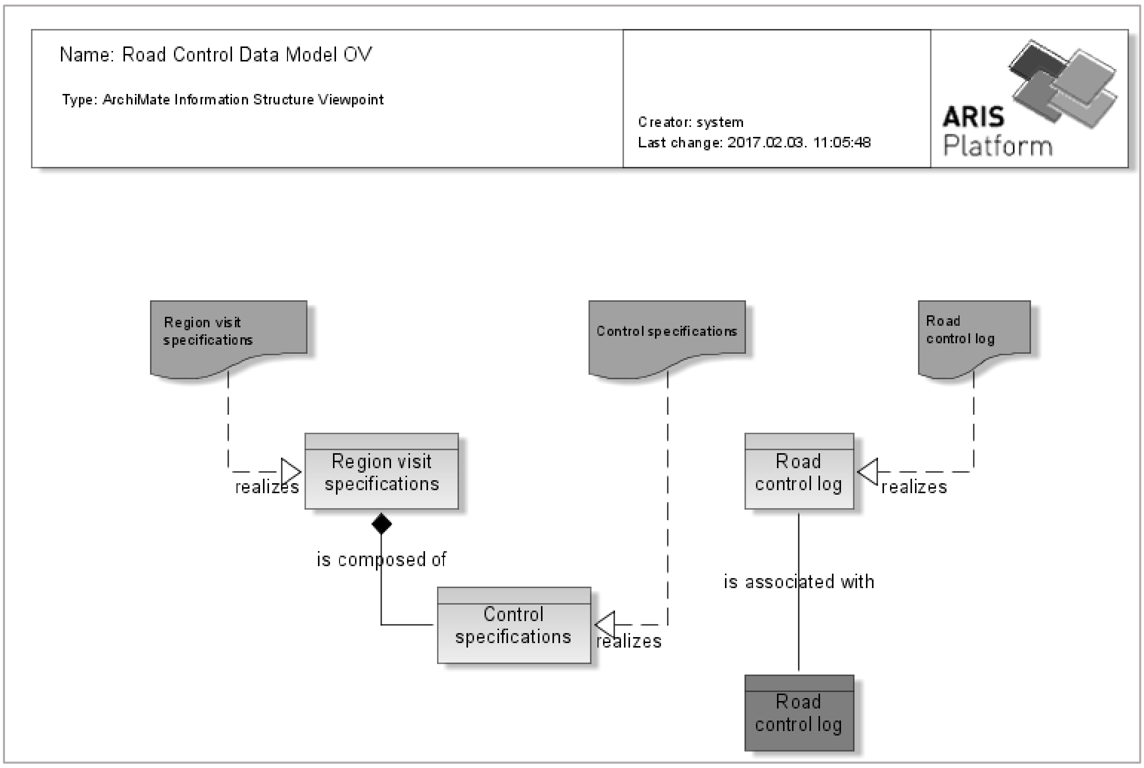


Figure 46. Road Control Data Model OV Model Representation for Misalignment Symptom S.32

Figure 47 shows an excerpt from Road Control Data Model OV XML export for the detection of misalignment symptom S.32. The excerpt contains an object definition node from the type of data entity (TypeNum=”OT_CLST”) with an attribute definition element for the data owner of the data entity (AttrDef.Type=”AT_RESP_PERS”).

```
<ObjDef ObjDef.ID="ObjDef.5V9fxba5k_H-p-L"
    TypeNum="OT_CLST"
    ToCxnDefs.IdRefs="   CxnDef.-6GlqpAHySru-q-L   "
    SymbolNum="ST_CLST"
>
    <AttrDef AttrDef.Type="AT_PERS_RESP">
        <AttrValue>
            <StyledElement>
                <Paragraph Alignment="UNDEFINED" Indent="0"/>
                    <StyledElement>
                        <PlainText TextValue="Road Inspectors"/>
                    </StyledElement>
            </StyledElement>
        </AttrValue>
    </AttrDef>
    <AttrDef AttrDef.Type="AT_NAME">
        <AttrValue>
            <StyledElement>
                <Paragraph Alignment="UNDEFINED" Indent="0"/>
                    <StyledElement>
                        <PlainText TextValue="Road Control Records"/>
                    </StyledElement>
            </StyledElement>
        </AttrValue>
    </AttrDef>
</ObjDef>
```

Figure 47. Excerpt from Road Control Data Model OV XML Export for Misalignment Symptom S.32

After reviewing relevant EA models and their XML export excerpts, the previously introduced general Schematron queries will be personalised to the suitable EA models. *Table 58* contains the customised queries for misalignment symptom detection. The expressions of rule context and assert or report test are provided with appropriate attributes and values from the EA models under review.

Table 58. Customised Schematron Queries for Misalignment Symptom Detection

Query Code	Symp-tom Code	EA Model under Review	Query Description
Q.01	S.02	▪ Road Control Process 1.0 ▪ Road Control Process 2.0	<pattern name="*S.02 Undefined business process goals, business process owners*"> <rule context="ObjDef[@TypeNum='OT_FUNC']"> <assert test="AttrDef[@AttrDef.Type= 'AT_PERS_RESP']"> *Alert: S.02 Undefined business process goals, business process owners* </assert> </rule> </pattern>
Q.02	S.05	▪ Road Control Roles and Reporting Lines	<pattern name="*S.05/A Undefined or multiple hierarchy or lines of reporting*"> <rule context="ObjDef[@TypeNum='OT_GRP']"> <report test="@ObjDef.ID=following-sibling::ObjDef[@TypeNum='OT_GRP']/CxnDef[@CxnDef.Type='CT_IS_SUPERIOR_1']/@ToObjDef.IdRef or @ObjDef.ID=preceding-sibling::ObjDef[@TypeNum='OT_GRP']/CxnDef[@CxnDef.Type='CT_IS_SUPERIOR_1']/@ToObjDef.IdRef"> Alert: S.05/A *Undefined or multiple hierarchy or lines of reporting* </report> </rule> </pattern> <pattern name="*S.05/B Undefined or multiple hierarchy or lines of reporting*"> <rule context="ObjDef[@TypeNum='OT_GRP']"> <report test="CxnDef[@ToObjDef.IdRef=parent::ObjDef/following-sibling::ObjDef[@TypeNum='OT_GRP']/CxnDef[@CxnDef.Type='CT_IS_SUPERIOR_1']/@ToObjDef.IdRef] or CxnDef[@ToObjDef.IdRef=parent::ObjDef/preceding-sibling::ObjDef[@TypeNum='OT_GRP']/CxnDef[@CxnDef.Type='CT_IS_SUPERIOR_1']/@ToObjDef.IdRef]"> Alert: S.05/B *Undefined or multiple hierarchy or lines of reporting* </report> </rule> </pattern>

(Continues)

Table 58. *(Continued)*

Query Code	Symp-tom Code	EA Model under Review	Query Description
Q.03	S.07	▪ Road Control System 1.0 with Services ▪ Road Control System 2.0 with Services	<pattern name="*S.07 Business process task supported by more than one application*"> <rule context="ObjDef[@TypeNum='OT_FUNC']"> <report test="count(CxnDef[@ToObjDef.IdRef= parent:: ObjDef/following-sibling::ObjDef [@TypeNum='OT_DP_ FUNC_TYPE']/@ ObjDef.ID or @ToObjDef.IdRef=parent:: ObjDef/preceding-sibling::ObjDef[@TypeNum='OT_DP_FUNC_TYPE']/ @ObjDef.ID])>1"> *Alert: S.07 Business process task supported by more than one application* </report> </rule> </pattern>
Q.04	S.16	▪ Technological Software Components ▪ Road Control System 1.0 Infrastructure Usage Model ▪ Road Control System 2.0 Infrastructure Usage Model	<pattern name="*S.16 Out of date technological infrastructure*"> <rule context="ObjDef[@TypeNum='OT_APPL_SYS_ TYPE']"> <assert test="AttrDef[@AttrDef.Type='AT_VERS_ REL']// PlainText[@TextValue=document('Techno logical Software Components.xml')//ObjDef[@Type Num='OT_APPL_SYS_TYPE']//AttrDef[@AttrDef. Type='AT_VERS_ REL']//PlainText//@TextValue]"> *Alert: S.16 Out of date technological infrastructure* </assert> </rule> </pattern>
Q.05	S.18	▪ Technological Hardware Components ▪ Road Control System 1.0 Infrastructure Usage Model ▪ Road Control System 2.0 Infrastructure Usage Model	<pattern name="*S.18 Incompatible platforms or technologies*"> <rule context="ObjDef[@TypeNum='OT_HW_CMP_ TYPE']"> <assert test="AttrDef[@AttrDef.Type='AT_NAME'] //Plain Text [@TextValue=document('Technological Hardware Components.xml')//ObjDef[@TypeNum= 'OT_HW_CMP_TYPE']//AttrDef[@AttrDef.Type= 'AT_NAME']//PlainText/@TextValue]"> *Alert: S.18 Incompatible platforms or technologies* </assert> </rule> </pattern>
Q.06	S.32	▪ Road Control Data Model OV ▪ Road Control Data Model 1.0	<pattern name="*S.32 Lack of data ownership*"> <rule context="ObjDef[@TypeNum='OT_CLST']"> <assert test="AttrDef[@AttrDef.Type= 'AT_PERS_RESP']">

(Continues)

Table 58. *(Continued)*

		▪ Road Control Data Model 2.0	*Alert: S.32 Lack of data ownership* </assert> </rule> </pattern>
Q.07	S.52	▪ Road Control Process 1.0 ▪ Road Control Process 2.0 ▪ Road Control Data Model 1.0 ▪ Road Control Data Model 2.0	<pattern name="*S.52 Not all data entities are read at least by one process*"> <rule context="ObjDef[@TypeNum='OT_CLST']"> <assert test="AttrDef[@AttrDef.Type='AT_NAME'] // PlainText [@TextValue=document('Road Control Process 1.0.xml')//ObjDef[@TypeNum='OT_CLST'] //AttrDef[@AttrDef.Type='AT_NAME']//PlainText// @TextValue]"> *Alert: S.52 Not all data entities are read at least by one process* </assert> </rule> </pattern>

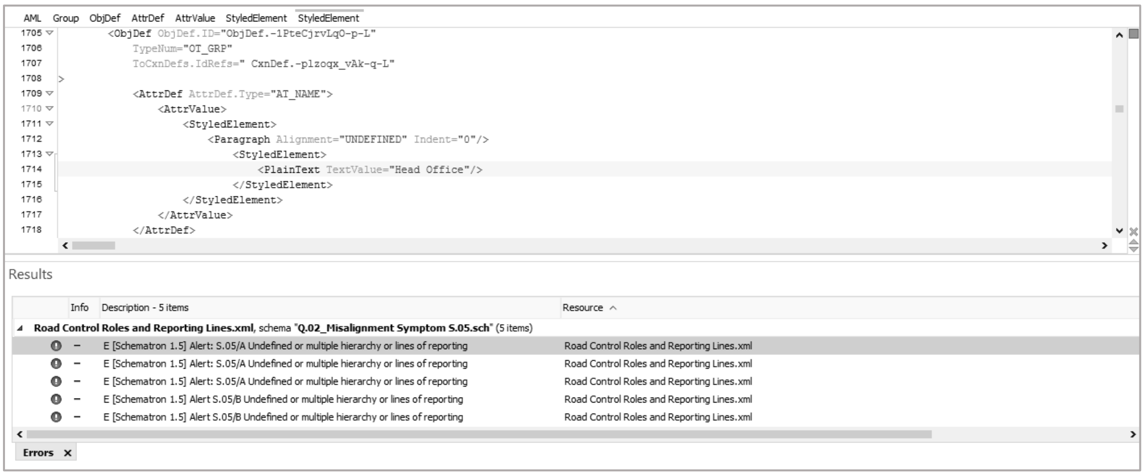
Sample procession results for Schematron queries are introduced in *Figure 48-60*. *Figure 48* illustrates the query of Q.02 in an XML Editor before XML validation. The query Q.02 was validated against the XML export of Road Control Roles and Reporting Lines. *Figure 49* contains a sample operation result out of the 5 results for running the query of misalignment symptom S.05.

schema pattern rule report

```
<?xml version="1.0" encoding="UTF-8"?>
<schema xmlns="http://www.ascc.net/xml/schematron" >
    <pattern name="S.05/A Undefined or multiple hierarchy or lines of reporting">
        <rule context="ObjDef[@TypeNum='OT_GRP']">
            <report test="@ObjDef.ID=following-sibling::ObjDef[@TypeNum='OT_GRP']/
                CxnDef[@CxnDef.Type='CT_IS_SUPERIOR_1']/@ToObjDef.IdRef or
                @ObjDef.ID=preceding-sibling::ObjDef[@TypeNum='OT_GRP']/
                CxnDef[@CxnDef.Type='CT_IS_SUPERIOR_1']/@ToObjDef.IdRef">
                Alert: S.05/A Undefined or multiple hierarchy or lines of reporting
            </report>
        </rule>
    </pattern>
    <pattern name="S.05/B Undefined or multiple hierarchy or lines of reporting">
        <rule context="ObjDef[@TypeNum='OT_GRP']">
            <report test="CxnDef[@ToObjDef.IdRef=parent::ObjDef/following-sibling::ObjDef[@TypeNum='OT_GRP']/
                CxnDef[@CxnDef.Type='CT_IS_SUPERIOR_1']/@ToObjDef.IdRef] or
                CxnDef[@ToObjDef.IdRef=parent::ObjDef/preceding-sibling::ObjDef[@TypeNum='OT_GRP']/
                CxnDef[@CxnDef.Type='CT_IS_SUPERIOR_1']/@ToObjDef.IdRef]">
                Alert S.05/B Undefined or multiple hierarchy or lines of reporting
            </report>
        </rule>
    </pattern>
</schema>
```

Figure 48. Schematron Query Q.02 for Misalignment Symptom S.05

Figure 50 illustrates the query of Q.03 in an XML Editor before XML validation. The query Q.03 was validated against the XML export of Road Control System 1.0 with Services. *Figure 51* contains operation results for running the query of misalignment symptom S.07.



```
AML  Group  ObjDef  AttrDef  AttrValue  StyledElement  StyledElement
        <ObjDef ObjDef.ID="ObjDef.-1PteCjrvLqO-p-L"
            TypeNum="OT_GRP"
            ToCxnDefs.IdRefs=" CxnDef.-plzoqx_vAk-q-L"
>
            <AttrDef AttrDef.Type="AT_NAME">
                <AttrValue>
                    <StyledElement>
                        <Paragraph Alignment="UNDEFINED" Indent="0"/>
                            <StyledElement>
                                <PlainText TextValue="Head Office"/>
                            </StyledElement>
                    </StyledElement>
                </AttrValue>
            </AttrDef>
```

Results

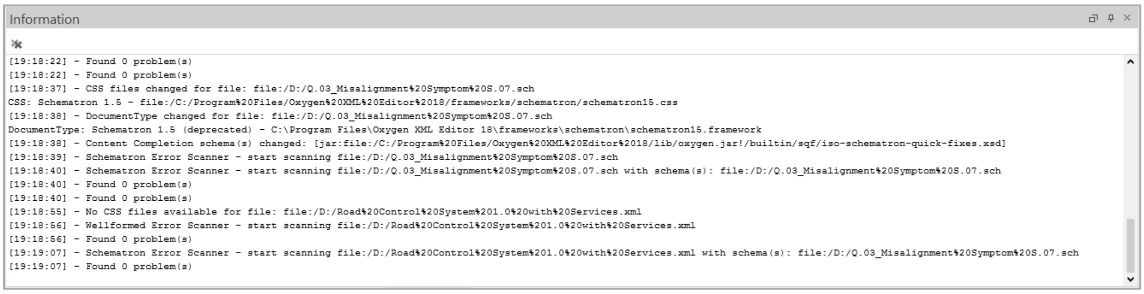
	Info	Description - 5 items	Resource
Road Control Roles and Reporting Lines.xml, schema "Q.02_Misalignment Symptom S.05.sch" (5 items)			
	–	E [Schematron 1.5] Alert: S.05/A Undefined or multiple hierarchy or lines of reporting	Road Control Roles and Reporting Lines.xml
	–	E [Schematron 1.5] Alert: S.05/A Undefined or multiple hierarchy or lines of reporting	Road Control Roles and Reporting Lines.xml
	–	E [Schematron 1.5] Alert: S.05/A Undefined or multiple hierarchy or lines of reporting	Road Control Roles and Reporting Lines.xml
	–	E [Schematron 1.5] Alert S.05/B Undefined or multiple hierarchy or lines of reporting	Road Control Roles and Reporting Lines.xml
	–	E [Schematron 1.5] Alert S.05/B Undefined or multiple hierarchy or lines of reporting	Road Control Roles and Reporting Lines.xml

Errors ×

Figure 49. Query Q.02 Output for Misalignment Symptom S.05 Processed on Road Control Roles and Reporting Lines

```
schema  pattern  rule  report
<?xml version="1.0" encoding="UTF-8"?>
<schema xmlns="http://www.ascc.net/xml/schematron" >
    <pattern name="S.07 Business process task supported by more than one application">
        <rule context="ObjDef[@TypeNum='OT_FUNC']">
            <report test="count(CxnDef[@ToObjDef.IdRef=parent::ObjDef/following-sibling::ObjDef[@TypeNum='OT_DP_FUNC_TYPE']/@ObjDef.ID or
                @ToObjDef.IdRef=parent::ObjDef/preceding-sibling::ObjDef[@TypeNum='OT_DP_FUNC_TYPE']/@ObjDef.ID])>1">
                Alert: S.07 Business process task supported by more than one application
            </report>
        </rule>
    </pattern>
</schema>
```

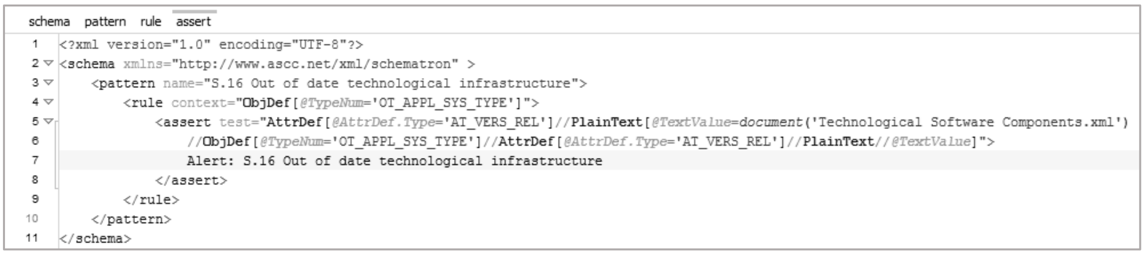
Figure 50. Schematron Query Q.03 for Misalignment Symptom S.07



```
Information
[19:18:22] - Found 0 problem(s)
[19:18:22] - Found 0 problem(s)
[19:18:37] - CSS files changed for file: file:/D:/Q.03_Misalignment%20Symptom%20S.07.sch
CSS: Schematron 1.5 - file:/C:/Program%20Files/Oxygen%20XML%20Editor%2018/frameworks/schematron/schematron15.css
[19:18:38] - DocumentType changed for file: file:/D:/Q.03_Misalignment%20Symptom%20S.07.sch
DocumentType: Schematron 1.5 (deprecated) - C:\Program Files\Oxygen XML Editor 18\frameworks\schematron\schematron15.framework
[19:18:38] - Content Completion schema(s) changed: [jar:file:/C:/Program%20Files/Oxygen%20XML%20Editor%2018/lib/oxygen.jar!/builtin/sqf/iso-schematron-quick-fixes.xsd]
[19:18:39] - Schematron Error Scanner - start scanning file:/D:/Q.03_Misalignment%20Symptom%20S.07.sch
[19:18:40] - Schematron Error Scanner - start scanning file:/D:/Q.03_Misalignment%20Symptom%20S.07.sch with schema(s): file:/D:/Q.03_Misalignment%20Symptom%20S.07.sch
[19:18:40] - Found 0 problem(s)
[19:18:40] - Found 0 problem(s)
[19:18:55] - No CSS files available for file: file:/D:/Road%20Control%20System%201.0%20with%20Services.xml
[19:18:56] - Wellformed Error Scanner - start scanning file:/D:/Road%20Control%20System%201.0%20with%20Services.xml
[19:18:56] - Found 0 problem(s)
[19:19:07] - Schematron Error Scanner - start scanning file:/D:/Road%20Control%20System%201.0%20with%20Services.xml with schema(s): file:/D:/Q.03_Misalignment%20Symptom%20S.07.sch
[19:19:07] - Found 0 problem(s)
```

Figure 51. Query Q.03 Output for Misalignment Symptom S.07 Processed on Road Control System 1.0 with Services

Figure 52 illustrates the query of Q.04 in an XML Editor before XML validation. The query Q.04 was validated against the XML export of Road Control System 1.0 Infrastructure Usage Model. *Figure 53* contains operation results for running the query of misalignment symptom S.16.



```
schema  pattern  rule  assert
<?xml version="1.0" encoding="UTF-8"?>
<schema xmlns="http://www.ascc.net/xml/schematron" >
    <pattern name="S.16 Out of date technological infrastructure">
        <rule context="ObjDef[@TypeNum='OT_APPL_SYS_TYPE']">
            <assert test="AttrDef[@AttrDef.Type='AT_VERS_REL']//PlainText[@TextValue=document('Technological Software Components.xml')
                //ObjDef[@TypeNum='OT_APPL_SYS_TYPE']//AttrDef[@AttrDef.Type='AT_VERS_REL']//PlainText//@TextValue]">
                Alert: S.16 Out of date technological infrastructure
            </assert>
        </rule>
    </pattern>
</schema>
```

Figure 52. Schematron Query Q.04 for Misalignment Symptom S.16

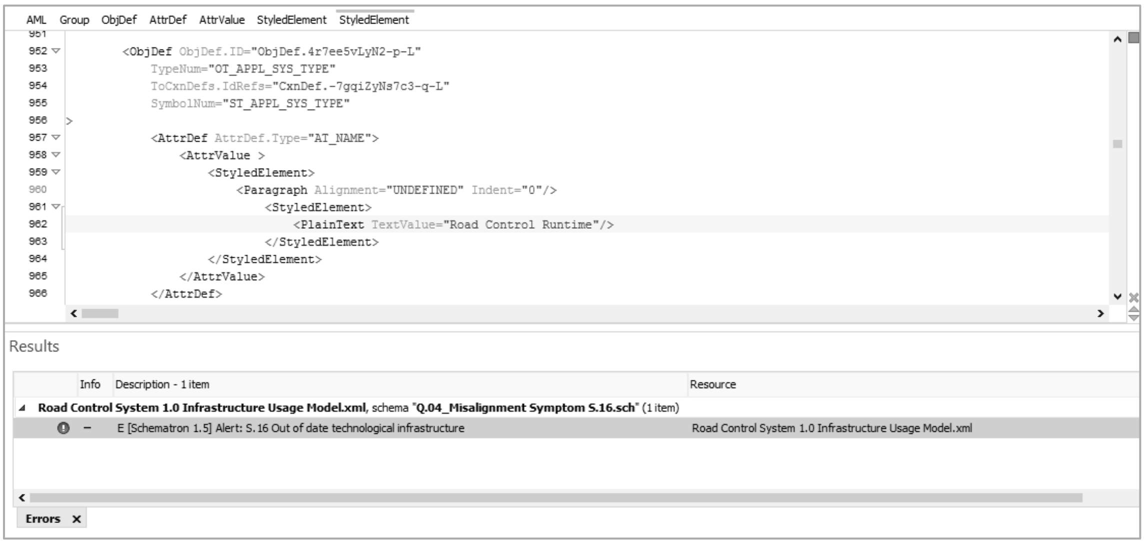


Figure 53. Query Q.04 Output for Misalignment Symptom S.16 Processed on Road Control System 1.0 Infrastructure Usage Model

Figure 54 illustrates the query of Q.05 in an XML Editor before XML validation. The query Q.05 was also validated against the XML export of Road Control System 1.0 Infrastructure Usage Model. *Figure 55* contains operation results for running the query of misalignment symptom S.18.

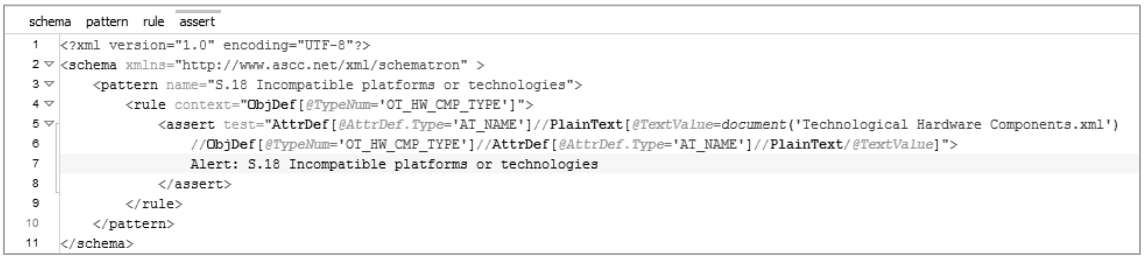


Figure 54. Schematron Query Q.05 for Misalignment Symptom S.18

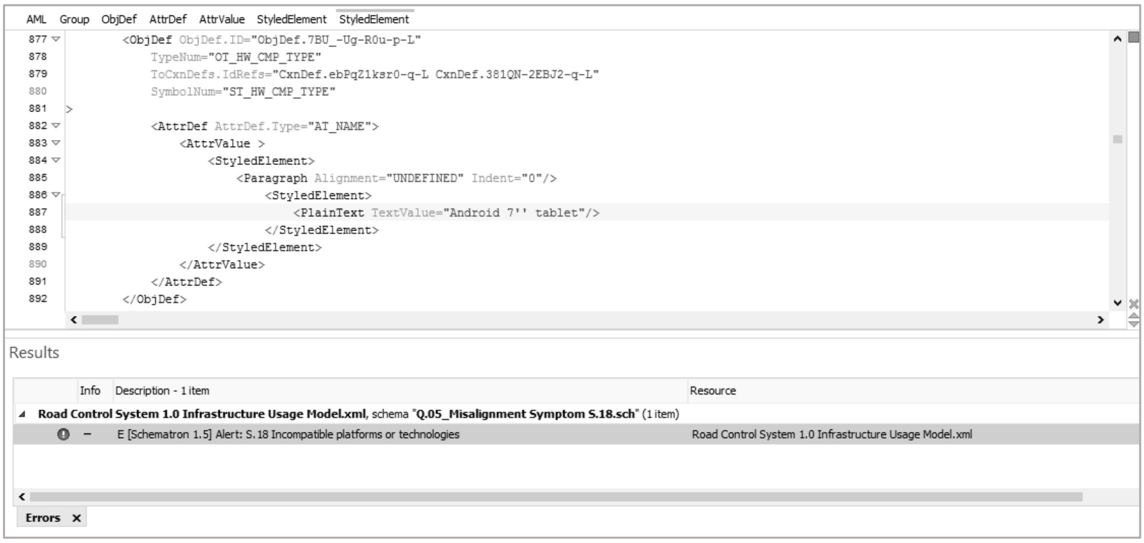


Figure 55. Query Q.05 Output for Misalignment Symptom S.18 Processed on Road Control System 1.0 Infrastructure Usage Model

Figure 56 illustrates the query of Q.06 in an XML Editor before XML validation. The query Q.06 was validated against the XML export of Road Control Data Model OV. *Figure 57* contains operation results for running the query of misalignment symptom S.32.

```
schema  pattern  rule  assert
<?xml version="1.0" encoding="UTF-8"?>
<schema xmlns="http://www.ascc.net/xml/schematron" >
    <pattern name="S.32 Lack of data ownership">
        <rule context="ObjDef[@TypeNum='OT_CLST']">
            <assert test="AttrDef[@AttrDef.Type='AT_PERS_RESP']">
                Alert: S.32 Lack of data ownership
            </assert>
        </rule>
    </pattern>
</schema>
```

Figure 56. Schematron Query Q.06 for Misalignment Symptom S.32

```
Information
[19:48:28] - Schematron Error Scanner - start scanning file:/D:/Q.06_Misalignment%20Symptom%20S.32.sch
[19:48:29] - Schematron Error Scanner - start scanning file:/D:/Q.06_Misalignment%20Symptom%20S.32.sch with schema(s): file:/D:/Q.06_Misalignment%20Symptom%20S.32.sch
[19:48:29] - Found 0 problem(s)
[19:48:29] - Found 0 problem(s)
[19:48:36] - Schematron Error Scanner - start scanning file:/D:/Q.06_Misalignment%20Symptom%20S.32.sch
[19:48:37] - Schematron Error Scanner - start scanning file:/D:/Q.06_Misalignment%20Symptom%20S.32.sch with schema(s): file:/D:/Q.06_Misalignment%20Symptom%20S.32.sch
[19:48:37] - Found 0 problem(s)
[19:48:37] - Found 0 problem(s)
[19:49:35] - Schematron Error Scanner - start scanning file:/D:/Q.06_Misalignment%20Symptom%20S.32.sch
[19:49:35] - Schematron Error Scanner - start scanning file:/D:/Q.06_Misalignment%20Symptom%20S.32.sch with schema(s): file:/D:/Q.06_Misalignment%20Symptom%20S.32.sch
[19:49:35] - Found 0 problem(s)
[19:49:35] - Found 0 problem(s)
[19:49:42] - Schematron Error Scanner - start scanning file:/D:/Road%20Control%20Data%20Model%20OV.xml with schema(s): file:/D:/Q.06_Misalignment%20Symptom%20S.32.sch
[19:49:42] - Found 0 problem(s)
```

Figure 57. Query Q.06 Output for Misalignment Symptom S.32 Processed on Road Control Data Model OV

Figure 58 illustrates the query of Q.07 in an XML Editor before XML validation. The query Q.07 was validated against the XML export of Road Control Data Model 1.0. *Figure 59* and *Figure 60* contain operation results for running the query of misalignment symptom S.52.

```
schema  pattern  rule  assert
<schema xmlns="http://www.ascc.net/xml/schematron" >
    <pattern name="S.52 Not all data entities are read at least by one process">
        <rule context="ObjDef[@TypeNum='OT_CLST']">
            <assert test="AttrDef[@AttrDef.Type='AT_NAME']//PlainText[@TextValue=document('Road Control Process 1.0.xml')
                //ObjDef[@TypeNum='OT_CLST']//AttrDef[@AttrDef.Type='AT_NAME']//PlainText//@TextValue]">
                Alert: S.52 Not all data entities are read at least by one process
            </assert>
        </rule>
    </pattern>
</schema>
```

Figure 58. Schematron Query Q.07 for Misalignment Symptom S.52

This section has introduced the process of misalignment symptom detection. Firstly, road control EA models were added to every misalignment symptom under detection. Secondly, EA model representations were presented in both graphical and XML views. Thirdly, queries were customised to the road control EA models. Finally, exemplary processing outputs were added on misalignment symptom detection to prepare for the subsequent, results interpretation section.

Figure 59. Query Q.07 Output/A for Misalignment Symptom S.52 Processed on Road Control Data Model 1.0

Figure 60. Query Q.07 Output/B for Misalignment Symptom S.52 Processed on Road Control Data Model 1.0

4.7 Interpretation of Results

This section presents the interpretation of misalignment symptom detection. First, every processing output under detection will be evaluated and interpreted in detail. Constraints and possible extensions will also be introduced in this part of the section. The summary of output interpretation is extended with the documentation of follow-up interviews for result validation. The subsection ends with the summary of results interpretation to prepare the reader for case discussion.

Misalignment symptom S.02 was validated against the EA models of Road Control Process 1.0 and Road Control Process 2.0 by the query of Q.01 looking for the lack of business process owners. There were no business processes without business process owners either in 1.0 or in 2.0 version. As for constraints, the query validated only the lack of business process owners. The lack of business process goals was not investigated in the case study because there was no modeling instance for business process models with business process goals. A possible extension is that the query also examines the presence or lack of business process goals on an appropriate EA model in the road control initiative. Another constraint was that the query did not examine whether or not a business process needs an owner. There must be cases where business processes do not need a business process owner, e.g. if a business process is atomic with only one business process task. This examination is not included in the query, therefore another possible extension is to alter the query to investigate this stipulation as well. As for results validation in practice, the follow-up interviews revealed that the case context sets that business processes (business process tasks which are represented as business processes in the EA models of the case organisation) with superior business processes do not need a business process owner. In this sense, the query reveals the general state of business processes in terms of business process owners, but further examination is needed to narrow the query with the previously introduced stipulation. However, in this state of the EA models, there is no instance on attribute level that would indicate the superior or subordinated manner of a business process task.

Misalignment symptom S.05 was validated against the EA model of Road Control Roles and Reporting Lines by the query of Q.02 looking for multiple lines of reporting. This statement narrows the scope of the query, i.e. undefined lines of reporting were not examined by the query. The query contained 2 parts: S.05/A was concerned with a structural examination, i.e. whether the business collaboration element has a valid subordinated element. The query for S.05/A indicated the three business collaboration elements which have a valid subordinated element: 1) Road information department, 2) 2nd level dispatcher service and 3) 3rd level dispatchers. S.05/B examined whether a subordinated element has the same superior element with another subordinated element. The query for S.05/B indicated the 2nd level dispatcher service which has two subordinated dispatcher services: 3rd level dispatchers and line dispatchers. A possible extension of the query is to examine the undefined lines of reporting as well. Follow-up interviews revealed that the query explores a real misalignment problem in the road control initiative. The 2nd level dispatcher service works 0-24 throughout the year. However, the particular subordinated dispatcher service depends on winter/summer shifts and working hours. E.g. in the final minutes of duty time there might be two parallel reporting lines at the same time due to poor regulation compliance or geographical distance.

Misalignment symptom S.07 was validated against the EA models of Road Control System 1.0 with Services and Road Control System 2.0 with Services by the query of Q.03. Misalignment symptom S.07 was not detected in EA model Road Control System 1.0 with Services. Result called “Found 0 problem(s)” means that there was no business process task in EA model Road Control System 1.0 with Services with more than 1 supportive application. As for Road Control System 2.0 with Services, the query has the same result, i.e. there was no business process task in the 2.0 model variant with more than 1 supportive application. In terms of setting constraints to the query, note that the distinction between applications and application functions is necessary. In the EA models under review application functions were connected to business process tasks instead of applications. Business process tasks with more than one supportive application function do not imply the presence of the misalignment symptom in question. Misalignment problems arise if more than one supportive application is connected to a business process task. In this sense, the query was not able to detect the symptom precisely due to the depth of modeling. There was no modeling instance for supportive applications only for supportive application functions per business process tasks. Therefore, the query could not measure the cardinality of supportive applications, but only the cardinality of supportive application components to business process tasks. A possible extension of the symptom detection is to repeat the investigation after having the necessary modeling instances. Follow-up interviews to validate the symptom revealed that the EA models under review contained application functions instead of applications. In this sense, the above-introduced extension is needed to detect the cardinality of applications.

Misalignment symptom S.16 was validated against the EA models of Road Control System 1.0 Infrastructure Usage Model and Road Control System 2.0 Infrastructure Usage Model by the query of Q.04. In both cases the models were compared with the EA model of Technology Software Components with valid components, looking for out of date technological infrastructure in the infrastructure usage models. As for model variant 1.0, the query detected one out of date technological infrastructure component, namely the IIS 7.0 runtime engine which is not included in the list of valid technological infrastructure elements. For model variant 2.0 the query detected the IIS 7.5 runtime engine, which is a supported infrastructure element, but it is not provided with the version attribute in the Technological Software Components model. This case forms a constraint to the query. Follow-up interviews revealed that some elements are not provided with version attribute in the Technological Software Components model (among others IIS 7.5). The query detects the lack of related infrastructure elements as well, this is why the symptom is also violated in the 2.0-version infrastructure usage model. According to results validation, two possible extensions can be made to correct the query: 1) to add the lacking version attributes in the EA models, 2) to narrow the scope of the query.

Similar to misalignment symptom S.16, misalignment symptom S.18 was also validated against the EA models of Road Control System 1.0 Infrastructure Usage Model and Road Control System 2.0 Infrastructure Usage Model. The query of Q.05 used the EA model of Technology Hardware Components for comparing the infrastructure usage models with the list of valid hardware components. In this query, incompatible platforms and technologies were explored. For model variant 1.0, the query detected one incompatible hardware component, namely the Android 7'' tablet which is not included in the list of valid technological infrastructure elements. However, in model variant 2.0 the symptom was not detected. This is a good example for analysing and detecting misalignment symptoms over time: While model variant 1.0 contained an incompatible element, the incompatibility was corrected over time, and for the next version of the model there was no violation of this kind of incompatibility. Follow-up interviews also confirmed that the incompatibility in model version 1.0 was corrected in model version 2.0. While the road control initiative had an incompatible infrastructure element during the progression of the project, it was later corrected and in the end, model version 2.0 lacks the incompatible element.

Misalignment symptom S.32 was validated against the EA models of Road Control Data Model OV, 1.0 and 2.0 by the query of Q.05 to detect missing data owners. The validation against the original version did not detect any problem. The validation against the 1.0 and 2.0 versions both detected 1 data entity without a data owner, namely the data entity called Road network related objects. Similar to misalignment symptom S.02, a possible extension is to examine whether or not a data entity needs an owner. There must be cases when data entities do not need a data owner. This examination is not included in the query, therefore a possible extension is to alter the query to investigate this stipulation as well. Follow-up interviews on results validation confirmed that there are data entities in the road control initiative which have no data owner, ergo the query worked properly in this case.

Finally, misalignment symptom S.52 was validated against Road Control Process 1.0 and Road Control Process 2.0 by the query of Q.06 to explore unused data entities. The query used the EA model of Road Control Data Model 1.0 and Road Control Data Model 2.0 respectively to compare the business process models with the list of data entities. Both the validation against 1.0 and 2.0 versions detected 2 unused data entities. Contrary to the overtime incompatibility checking in misalignment symptom S.18, the malfunction was not corrected during the progress of the initiative. The query has one major potential for extension. Similar to data usage checking, the examination can be extended to other usage checks as well. Follow-up interviews on results validation verified that there are unused data entities in the road control initiative, ergo the query worked well in this case. Interviews also confirmed that there is a need for query extension in terms of similar usage checks. Appropriate EA models have to be sorted out to detect other kinds of usage checks.

This section has introduced the interpretation of misalignment symptom detection. Symptoms were interpreted in detail as well as constraints and possible extensions were presented in this section. At the same time, follow-up interviews for results validation were documented to interpret the results in case context. In the following subsection, results will be discussed and conclusions will be drawn concerning the case study under review.

4.8 Discussion

In this subsection, discussion will be provided about misalignment symptom detection at the case organisation. The case study will be first summarised in terms of research framework usability. Subsequently, conclusions will be drawn concerning the proposed research framework and the case study under review.

Misalignment symptom analysis and detection provided insights about query types. Evidence from the case study suggested that there are distinct types of misalignment symptoms that can be detected by the proposed research framework. The case study demonstrated that the proposed research framework is applicable for detecting the following types of misalignment symptoms:

1) Symptoms in which the presence or lack of the certain types of attributes has to be investigated (e.g. S.02, S.32).
2) Symptoms in which the cardinality of certain connection types has to be analysed. This type is applicable to three cases: Firstly, one particular model is analysed in terms of connection cardinality (e.g. S.05). Secondly, sole model variants are analysed in terms of connection cardinality and the query is processed for every available model variant (e.g. S.07). Thirdly, model variants under review are analysed with another type of static or dynamic EA model in terms of connection cardinality. The expressiveness of the query language provides this kind of analysis. However, the case study did not provide any example of this kind of analysis.
3) Symptoms in which more models have to be compared (e.g. S.16, S.18, S.52). This type is applicable to two cases: Firstly, model variants have to be compared with another group of model variants according to the project phases (e.g. S.52). Secondly, model variants have to be compared with a static catalogue (e.g. S.16, S.18).

4) Symptoms in which more model variants have to be analysed and compared during the progression of the project (e.g. S.18).

Appendix L lists the above-collected archetypes of Schematron-based queries.

Apart from the previous categorisation, the case study also demonstrated that particular symptoms have to be detected in more than one step, viz. by more than one rule. Misalignment symptom S.05 was a spectacular example of this kind of analysis. As part of future work, other misalignment symptoms can be broken down into more than one rule.

With this categorisation considerable insight has been gained and significant progress has been made with regard to the applicability of the proposed framework in practice. Nevertheless, these findings have also revealed some areas of research limitations, which will be detailed in the following section.

To conclude, Section 4 was concerned with illustrating the applicability of the proposed research framework. To assess the state of misalignment at the road management authority, the proposed research framework was used. After case organisation introduction some details were provided about the road control initiative under review. Subsequently, EA model structure was introduced both for the entire road management authority and the road control initiative. After introductory subsections, a preliminary review was given about the precursory interviews on influential business-IT areas, specialties in model structure and malfunctioning areas. The section has continued with misalignment symptom analysis. In this subsection malfunctioning areas were translated into misalignment symptoms as well as symptoms were analysed according to the corresponding frameworks from the research methodology section. The subsection ended with general Schematron queries to the misalignment symptoms under investigation. After the detailed analysis misalignment symptom detection was performed. In this subsection, first affected EA models were introduced with influential details in both graphical and XML views. It was followed by the customisation of Schematron queries to the EA models of the road control initiative. Subsequently, procession results and output files were introduced for the queries. The interpretation of the results was presented in the next subsection together with the introduction of constraints, possible extensions for each misalignment symptom. In this subsection, results of follow-up validation were also introduced in order to provide interpretation of the procession results in the context of the project under review.

The case study provided considerable insight into the applicability of the proposed research framework. In addition, it has demonstrated the utility and usability of the proposed framework as well. The detection results confirmed the usefulness of the proposed research framework as a misalignment assessment framework Further analyses – which will be presented in the future work section – will show additional results for misalignment symptom detection.

5 CONCLUSION AND SUMMARY

The Ph.D. dissertation dealt with the concept of enterprise architecture-based misalignment analysis. It is a post-implementation assessment, which evaluates the (dis)harmony between business and IT. The Ph.D. dissertation presented a research approach for EA-based misalignment assessment. The main purpose of the proposed research was to analyse strategic misalignment between the business dimension and the information systems dimension. The research addressed misalignment symptom analysis by introducing an enterprise architecture-based framework to detect the typical signs of misalignment in an organisation.

After introducing the significance of the topic a literature overview was given on research foundation and the topics of 1) strategic alignment, 2) misalignment and 3) enterprise architecture. It was followed by a succinct introduction to EA-based alignment assessment techniques, with special attention to recent literature on EA-based alignment and misalignment analysis. Building block definition and the introduction of recent studies on the topic enabled us to draw up the research outline. In the methodology, section research methodology choices were given first. They were followed by a collection of competing methods. After methodologically contextualising the research problem, the proposed framework and the proposed research methodology were introduced in detail. The proposed framework was built on three layers: 1) Misalignment Layer, 2) EA Model Layer and 3) Analysis Layer, which were introduced in detail in Section 3.5.1. The proposed research methodology was introduced step-by-step, showing the building blocks as well as the operation of the proposed framework. The section concluded with the implementation details of generating and testing rules which were transformed from misalignment symptoms. To demonstrate the applicability of the proposed framework, a case study was shown. The empirical validation section contained all the analysis results on EA-based misalignment assessment.

5.1 Discussion

The main objective of the proposed research lies in identifying ways for detecting the symptoms of misalignment in the underlying EA models. The sub-objectives break down the research objective into smaller, logically connected parts along the conceptual structure, i.e. misalignment symptom identification, formal description of misalignment symptoms and formal methods of EA analysis. The proposed research applies a mixed research methodology to address the research objectives. In this mixed approach, the methods of Design Science Research and Case Study Research are combined to support the construction and empirical validation of the research model.

The construction and operation of the framework have been discussed and explained in detail in the previous sections. To illustrate the feasibility of the proposed framework in practice as well as to provide guidance on applicability, a case study was performed. Examples of mismatches have been provided in the investigated EA models by using the proposed artefact-based and EA analysis-based approach. The patterns of mismatches were analysed in detail in the empirical validation section. The findings validated the usefulness of the proposed research framework as a misalignment assessment tool.

The Ph.D. dissertation provided a complex framework for detecting misalignment symptoms in complex EA model structure. The research framework has highlighted significant analytical potential compared to the inbuilt query power of sole EA modeling tools. The relevance of the proposed research framework against the simple and usually limited analytical potential of EA modeling tools was clearly demonstrated by the in-depth analysis in the empirical validation section. In addition, the study provided support for transforming misalignment symptoms into misalignment queries via rule generation and rule testing techniques. The methodological steps of this transformation were summarised in Section 3 Research Methodology, while the practical use of converting misalignment symptoms into misalignment queries was demonstrated in detail in the empirical validation of the proposed framework (Section 4). The Ph.D. dissertation has also devised a methodology for misalignment symptom categorisation in which the EA-based applicability of the framework was investigated. Preliminary results (*Appendix G*) and the detailed analysis in empirical validation part provide evidence for the utility of the provided symptom categorisation scheme.

The study has also given an account for symptom validation. In the Ph.D. dissertation validation was accomplished by follow-up interviews at the case organisation after successfully operating the proposed research framework. The topic of validation raises two concerns which have to be clarified. First, the proposed research framework does not provide the potential for matching the EA models under review with an ideal model. This approach would imply the existence of an ideal, aligned model which can be used for benchmark. The presence of a fully aligned model base at case organisations would elicit the need for further alignment steps. Thus, this kind of matching cannot be accomplished, and the proposed framework does not deal with the analysis of this kind of ideal alignment model base. Second, the preliminary validation of misalignment symptoms cannot be done due to the specific follow-up interpretations of misalignment phenomena at the test organisations. There is no need for the in vitro testing of misalignment symptoms, i.e. the preliminary interpretation and evaluation of misalignment symptoms. This kind of validation also involves a reference model about the ideal state of the case organisation, against that an organisation can evaluate the presence of misalignment symptoms in advance. In contrast to the need for in vitro testing, the proposed framework uses a soft, follow-up validation based on post factum interviews and the interpretation of specific organisational characteristics and organisational context.

5.2 Limitations

Based on the experience gathered during framework and empirical validation, the proposed research framework has limitations on the following areas.

The first is that the framework examines only the model environment, i.e. the details that are modeled. In fact, the real operation of the organisations cannot be investigated, only the part which is presented at the modeling level. This observation recalls the need for investigating the state of models and the difference between models and reality in form of further follow-up interviews. Future work will concentrate on solving this issue.

The second limitation is the problem of modeling tool lock-in and document format lock-in. The same misalignment symptoms in different modeling tools and in different document formats have to be defined in a different way, which undermines the portability of the proposed framework. The model base of the case organisation clearly demonstrated how the ARIS tool and its special XML export format, the AML restricted the development of misalignment queries. This limitation could be solved by an intermediate transformation layer between the layer of documents under review and the layer of misalignment rule generation. This topic is also deferred to future work. Another way to solve the problem of lock-ins is to use XSLT transformation language to filter the relevant analysis details from documents in different formats. This approach would make the models in different document formats comparable for processing detection of the same misalignment symptom. Further work needs to be carried out to implement the standardisation of different document formats.

5.3 Conclusions

Conclusion section includes a summary of results organised by Research Objectives. *Table 59* gives a conclusion on how research objectives (RO1-RO3) have been addressed in the Ph.D. dissertation. Research objectives are contrasted with the accomplishments of the Ph.D. dissertation in order to show evidence for addressing research objectives in the dissertation. In the following summary positions of the research results and accomplishments are also pointed out to support traceability of evidence.

Table 59. Addressed Research Objectives

RESEARCH OBJECTIVE	ISSUE COVERED BY
RO1 What are the typical symptoms of misalignment according to the operation of the SAM model?	The framework includes misalignment symptom categorisation according to traditional alignment perspectives and alignment types (a.k.a. perspective components) in Section 3.5.2.
RO2 How to transform misalignment symptoms into formally analysable statements?	Misalignment symptoms are managed as formal rules. The proposed framework in Section 3.5 processes rules via XML validation techniques.
RO3 What are the formal analysis methods of detecting misalignment symptoms in enterprise architecture models?	In Section 3.4 a concept categorisation is given on competing methods for EA-based misalignment symptom detection. In addition, the proposed framework in Section 3.5 serves as a formal analysis method for the research topic.

In Section 3.4.5 Research Questions were contrasted to the corresponding concepts from the concept categorisation part in Section 4. In Section 3.5.1, as part of conceptual design, the 3-layer research concept was validated against the proposed research questions. In addition, in this subsection, research questions are contrasted with the specific solutions of the dissertation, which are provided throughout the study for answering research questions. To rehearse the above-introduced bindings and to point out the parts of the Ph.D. dissertation where research questions are answered, the following summary is given:

RQ1: WHICH MISALIGNMENT SYMPTOMS CAN BE DETECTED VIA ENTERPRISE ARCHITECTURE ASSESSMENT?

CORRESPONDING CONCEPTS:
3.4.2 Means of Symptom Analysis

CORRESPONDING RESEARCH LAYER:
3.5.1.1 Misalignment Layer

SOLUTION PROVIDED:

The proposed framework consists of an assessment tool (Section 3.5.2, *Table 27*) for architecture-scope misalignment symptoms. Architecture-scope misalignment symptoms are further examined in Section 3.5.2 for providing EA-based queries.

RQ2: WHICH DIMENSIONS AND DOMAINS ARE NEEDED TO EXAMINE IN AN EA MODEL TO DETECT MISALIGNMENT SYMPTOMS?

CORRESPONDING CONCEPTS:

3.4.1 Review of Business and IT Areas
3.4.3 Overview of Organisational Models

CORRESPONDING RESEARCH LAYER:
3.5.1.1 Misalignment Layer

SOLUTION PROVIDED:
The proposed framework consists of an assessment tool (Section 3.5.2, *Table 28*) for EA models and specific model elements to be investigated for misalignment symptom detection.

RQ3: HOW DO EA MODELS MANIFEST DIFFERENT MISALIGNMENT SYMPTOMS?

CORRESPONDING CONCEPTS:

3.4.3 Overview of Organisational Models
3.4.5 Directions for Implementation

CORRESPONDING RESEARCH LAYER:
3.5.1.2 EA Model Layer

SOLUTION PROVIDED:
Listing specific model elements and pattern queries in Section 3.5.2, *Table 28* provides tracking for misalignment symptom manifestation.

RQ4: WITH WHICH METHODS CAN WE EXPLORE THE DIFFERENT MISALIGNMENT SYMPTOMS IN EA MODELS?

CORRESPONDING CONCEPTS:

3.4.2 Means of Symptom Analysis
3.4.4 Means of Model Analysis
3.4.5 Directions for Implementation

CORRESPONDING RESEARCH LAYER:
3.5.1.3 Analysis Layer

SOLUTION PROVIDED:
A concept categorisation is given on competing methods for EA-based misalignment symptom detection in Section 3.4. The proposed framework in Section 3.5 serves as a formal analysis method for the research topic.

5.4 Significance and Rationale

In this Ph.D. dissertation, a new way of misalignment symptom detection has been presented, which is able to reveal typical symptoms along the four traditional alignment perspectives by assessing the underlying EA models. The proposed artefact-based misalignment detection framework is built on matching the symptoms of misalignment with possible containing artefacts and suitable EA analysis types along alignment perspectives.

The proposed research framework has the potential to extend our understanding on assessing the state of misalignment in a complex EA model structure. The framework allowed us to identify and detect malfunctioning procedures along the alignment perspectives. It highlighted the importance of and need for both an artefact-based and an EA analysis-based approach.

The novelty of the study lied in: 1) approaching the phenomenon of alignment from misalignment perspective, 2) using a symptom-based approach to detect the state of misalignment in an organisation, 3) using the concept of EAM to perform misalignment symptom detection and 4) applying rule testing and XML validation techniques in EA environment.

5.5 Research Contributions

The research contributed to alignment assessment and architecture alignment by proposing a model for EA-based misalignment assessment. The relevance of the study lied in the EA-based approach of assessing (mis)alignment. The proposed framework formed a well-structured method to analyse EA models.

The main contribution of the study was that it connected typical misalignment symptoms to suitable EA analysis methods along the perspectives of the SAM model. The specific contributions of the research were:

1) to assess the state of alignment from the perspective of misalignment,
2) to transform misalignment symptoms into formally analysable patterns and statements,
3) to detect the symptoms of misalignment in a structured and formal manner,
4) to perform misalignment assessment by using EA analysis techniques and
5) to provide formal analysis tools for EA model assessment.

For general contributions, the construction and operation of the research framework resulted in contributions to the applicability of enterprise architecture management from a business perspective. The proposed framework provided new attitudes, analytical tools and methods to support EA planning and control. In addition, the proposed research framework extended available theoretical frameworks on misalignment symptom analysis. Finally, it also contributed to organisational assessment toolkits in order to reinforce misalignment detection in practice.

5.6 Expected Results and Research Outcomes

The research produced structured data on the symptoms of misalignment. *Table 60* summarises the comparison of expected results and research outcomes. Research outcomes are connected to expected outcomes (listed in the Introduction section) in order to present the fulfillment of research objectives. Research outcomes also provide the location of the accomplishment within the dissertation.

In a broad sense, the usage of the proposed framework facilitated and eased the planning and evaluation of IT service portfolio in large, complex and heterogeneous organisations. In addition, it supported the development of strategic directions. The results of successfully operating the proposed model addressed two concerns: 1) On the one hand, it confirmed the compliance and relevance of misalignment patterns described from existing, real-world misalignment symptoms. 2) On the other hand, it verified the proper construction and operation of the analysis methods provided.

Organisations using the proposed framework will be able to assess the state of alignment by detecting strategic and structural mismatches in their EA models. Organisations 1) that are not aware of why different operational difficulties arise, as well as organisations 2) that are not in the state of alignment will receive an instrument which is able to reveal poorly-working procedures, non-supported processes and redundancies in different organisational areas. The proposed framework will help organisations to correct these strategic and structural deficiencies by showing the content and the location of the mismatches found in their EA models. In addition, by formally analysing their EA models, organisations will also be able to reveal further operational characteristics that can be utilized as e.g. indicators for new strategic directions.

Table 60. Expected Results and Research Outcomes

RESEARCH OUTCOME	EXPECTED OUTCOME
A classification scheme was proposed in Section 3.4 1) for EA-based indicators on misalignment and 2) for EA-based misalignment symptom detection methods.	EO1 Classification of different misalignment symptoms: EA indicators on misalignment, EA detection techniques
An EA-based misalignment assessment framework was proposed in Section 3, which is able to reveal the mismatches between the different alignment domains in the underlying EA models.	EO2 A framework which can support EA-based alignment assessment
Results were produced in the form of a case study in Section 4. Case analysis demonstrated the operation, correctness, relevance and accuracy of the framework.	EO3 Case studies on the operation, correctness, relevance, accuracy and results of the framework

5.7 Directions for Future Research

With the proposed research framework and the case study, considerable progress has been made with regard to the theoretical construction and practical application of EA-based misalignment assessment. However, the proposed research also encounters some challenges and questions in need of further investigation. Apart from the topics listed in the research framework limitation part (Section 5.1), the proposed framework clearly has some additional limitations. Topics reserved for further examination include among others: 1) the automatization of EA analysis types and 2) decoupling the framework from built-in EA tool features.

The next research step will be to focus on a tool-independent, automated implementation of the artefact-based misalignment symptom detection framework. In the meantime, a general assessment framework will be developed on alignment performance, which will be able to give feedback in the investigated organisations. Feedback will include both alignment performance evaluation and possible misalignment correction and realignment activities.

Apart from automating the framework, there are also less radical development initiatives. As part of future work, the approach will be evaluated against some set of testable criteria. The framework can be extended by analysing the supplementary alignment perspectives, i.e. the Organisation IT Infrastructure, Organisation Infrastructure Strategy, IT Organisation Infrastructure, IT Infrastructure Strategy perspectives. As indicated in the proposed research methodology, the framework can also be extended by the analysis of symptoms that cannot be managed and detected solely in EA scope (S.C.03). In this directive, additional sources will be included into the framework.

Future work will also focus on the dynamic nature of symptom detection, i.e. to analyse the different states of the EA models as well as the overarching changes in EA models over time. Research into solving this problem is already underway. A dynamic approach based on the traditional Strategic Alignment Process is in the process of investigation.

Future work will also concentrate on further refinements on the proposed framework. Symptom categorisation (S.C.01-S.C.03) for all the 71 misalignment symptoms is already in progress together with the alignment perspective-based classification of the entire misalignment symptom catalogue. In the former case, the rate of S.C.01 and S.C.02 symptoms would also indicate the practical applicability of the proposed research framework. (Note that a significant proportion of classification has already been done on empirical validation in Section 4. Nevertheless, future studies should target the entire categorisation of the entire symptom catalogue.) In the latter case containing EA models and relevant EA analysis types will also be added to the classification. In addition, hidden root causes have to be revealed as well as unaffected architecture domains have to be involved in the analysis. To enhance the accuracy and quality of misalignment symptom detection, misalignment symptom catalogues and recommended EA analysis collections can be expanded. Future studies should also address the report representation of Schematron-based queries. In this approach, the Schematron Validation Report Language (SVRL) would be used to report the results of misalignment symptom detection. Additionally, even more discussion is planned to provide its practical applicability. Since results are promising, the framework should be validated on some more complex EA model environments within other organisations. Finally, additional examination methods can be established in order to approach EA-based misalignment assessment from different points of view.

On a wider level, research is also needed to incorporate the methods of empirical research in the field of information systems. Additionally, an important issue to resolve for future studies is to examine the goodness of fit of the proposed framework with predefined fit measures. This area connects the proposed research to the fields of schema matching and ontology matching. Guidelines for future research in terms of this type of analysis with fit measures are given by Gerber et al. (2015) and Al Bouna et al. (2016). At the same time, the proposed research uses a soft validation technique based on follow-up interviews with case organisations on the detection results.

In the long term, this research will form the basis for additional studies on misalignment assessment. Several research directions can be developed by using the proposed research as an initial research approach. Different research steps propose further analysis potential. For instance, the generation of Description Logic statements provides input to ontology-based misalignment symptom analysis. Furthermore, different XML analysis techniques contain additional analysis potential for further EA domain-matching and XML matching studies.

From a methodological perspective, the research will serve as an initial composite of research design choices in the field of EA-based misalignment analysis. On the basis of the proposed research, further research design activities can be initiated in the field of EA-based misalignment assessment. Finally, the proposed research contributes to the instantiation of DSR-based IS studies, since it constructs a model using the DSR methodology.

In this section, conclusions were drawn about the proposed research. The section started with a discussion on the research results. It was followed by an introduction of research limitations. Subsequently, significance and rationale, research contributions and expected results were summarised and concluded. At the end of the section future research directions were determined.

APPENDICES

APPENDIX CODE	CONTENT
A	List of Acronyms
B	Misalignment Symptom Collections from Recent Literature on Misalignment
C	List of TOGAF Artefacts
D	Preliminary Results of SAM-based Misalignment Assessment
E	Preliminary Results of TOGAF-based Misalignment Assessment
F	Preliminary Results of Symptom Localisation
G	Preliminary Results of Perspective-based Symptom Analysis
H	Schematic Structure of AML Exports
I	Document Type Definition (DTD) for ARIS XML (AML)
J	Basic Elements of Schematron Query Language
K	Main XPath Operators for Schematron Queries
L	Archetypes of Schematron Queries

Appendix A: List of Acronyms

The glossary introduced in Appendix A is a collection of acronyms and terms used in the Ph.D. dissertation.

A1. List of Acronyms

ACRONYM	FULL TERM
ACMM	Architecture Capability Maturity Model
ADL	Architecture Definition Language
ADM	Architecture Development Method
ADML	Architecture Description Markup Language
AIM	Amsterdam Information Model
AML	ARIS Markup Language
ARIS	Architecture of Integrated Information Systems
ARISAN	ARIS Programming Language
BEAMS	Building Blocks for Enterprise Architecture Management Solutions
BITA	Business-IT Alignment
BMM	Business Motivation Model
BPA	Business Process Analysis
BPEL	Business Process Execution Language
BPM	Business Process Management
BPMN	Business Process Modelling Notation
BRM	Business Reference Modelling
BRM	Business Rule Management
BRMS	Business Rule Management System
CML	Conceptual Modelling Language
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
COBIT	Control Objectives for Information and Related Technologies
CSF	Critical Success Factor
CSR	Case Study Research
DCMI	Dublin Core Metadata Initiative
DL	Description Logic
DODAF	Department of Defense Architecture Framework
DOM	Document Object Model
DSL	Domain Specific Language
DSM	Domain Specific Modelling
DSML	Domain Specific Modelling Language
DSR	Design Science Research
DTD	Document Type Definition
EA	Enterprise Architecture
EAM	Enterprise Architecture Management
EAP	Enterprise Architecture Planning
EE	Enterprise Engineering
EM	Enterprise Modelling
FCL	Formal Contract Language
FEAF	Federal Enterprise Architecture Framework
GERAM	Generalized Enterprise Reference Architecture and Methodology
ICT	Information and Communication Technology
IDEF	Integrated DEFinition Methods

(Continues)

A1. *(Continued)*

Acronym	Full Term
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IM	Information Management
IS	Information Systems
ISACA	Information Systems Audit and Control Association
ISO	International Organisation for Standardization
IT	Information Technology
ITIL	Information Technology Infrastructure Library
ITSM	Information Technology Service Management
JS	JavaScript
KPI	Key Performance Indicator
MDA	Model Driven Architecture
MDE	Model Driven Engineering
MOF	Meta-Object Facility
OCL	Object Constraint Language
OMG	Object Management Group
OOP	Object-Oriented Programming
ORC	Object Role Calculus
ORM	Object-Relational Mapping
OWL	Web Ontology Language
QVT	Query/View/Transformation
RACI	Responsible, Accountable, Consulted, Informed
RDF	Resource Description Framework
REA	Resource-Event-Agent
RIF	Rule Interchange Format
RuleML	Rule Markup Language
RUP	Rational Unified Process
SAF	Strategic Alignment Framework
SAM	Strategic Alignment Model
SAP	Strategic Alignment Process
SBVR	Semantics of Business Vocabulary and Rules
SQL	Structured Query Language
SWRL	Semantic Web Rule Language
TOG	The Open Group
TOGAF	The Open Group Architecture Framework
UML	United Modelling Language
UMM	UN/CEFACT Modelling Methodology
XMI	eXtensible Metadata Interchange
XML	eXtensible Markup Language
XPath	XML Path Language
XPDL	XML Process Definition Language
XSD	eXtensible Schema Definition
XSLT	eXtensible Stylesheet Language Transformations
XQuery	XML Query Language

Appendix B: Misalignment Symptom Collections

This appendix contains different misalignment symptom collections found in the recent literature on misalignment.

B1. An Alignment Maturity Framework with Potential Areas for Misalignment Symptoms (Luftman, 2000)

Criteria	Misalignment Symptom
Communications	Minimum Understanding of Business by IT
	Minimum Understanding of IT by Business
	Casual, Ad-hoc Inter/Intra-organisational learning
	Protocol Rigidity, Command, and control
	Ad-hoc or Semi-structured Knowledge Sharing
	None or Ad-hoc Liaison(s) Breadth/Effectiveness
Competency/Value Measurements	Only Technical IT Metrics, Not related to business
	Ad-hoc Business Metrics, Not related to IT
	Ad-hoc, Unlinked Balanced Metrics
	Sporadically existing or Technical Service Level Agreements
	Not generally practiced or Informal Benchmarking
	Lack of Formal Assessments/Reviews or Some; Typically for problems
	Lack of or Minimum Continuous Improvement
Governance	Ad-hoc Business Strategic Planning or Basic planning at the functional level
	Ad-hoc or Functional tactical IT Strategic Planning
	Reporting/Organisation Structure: CIO reports to CFO
	Budgetary Control: Cost Centre; Erratic spending
	Cost-based IT Investment Management; Erratic spending
	Lack of formal/regular Steering Committee(s) or Periodic organised communication
	Reactive or Occasionally Responsive Prioritisation Process
Partnership	Business Perception of IT Value: IT Perceived as a cost of business
	IT does not play a role in Strategic Business Planning
	Shared Goals, Risk, Rewards/Penalties: IT takes (most of the) risk with little reward
	Ad-hoc IT Program Management
	Relationship/Trust Style: Conflict/Minimum
	Lack of Business Sponsor/Champion or Limited at the functional organisation
Scope & Architecture	The Scope of IT: Traditional (e.g. accounting, email)
	None or Ad-hoc Standards Articulation
	No formal architectural integration at Functional Organisation level
	No formal architectural integration at Enterprise level
	No formal architectural integration at Inter-Enterprise level
	Lack of or Limited Architectural Transparency, Flexibility
Skills	Discouraged Innovation, Entrepreneurship
	The Locus of Power is in the Business
	Management Style: Command and control
	Change Readiness: Resistance to change
	Lack of or minimum Career crossover
	Lack of or minimum Education, Cross-Training
	Minimum or Primarily transactional Social, Political, Trusting Environment

B2. Typical Symptoms of Misalignment Perceived in Organisations (Luftman, 2003)

MISALIGNMENT SYMPTOM
Poor understanding among IT and business
Projects not used, canceled, late
Competitive decline
Redundancies in systems development
Frequently fired IT managers
Absent systematic competencies
High turnover of IT professionals
System integration difficulties
Inappropriate resources
Unhappy users/complaints
Frequent IT reorganisations
Inconsistent project success rate
Lack of executive interest
Ill-performing, unstable technology
Lack of vision/strategy
High employee and/or customer turnover
No communication between IT and users
Low employee satisfaction
Ongoing conflicts between business and IT
Highly charged political environment
Unselective outsourcing of IT function
Slow time to market with products/services
Productivity decrease
Frequent escalation of daily operating issues to executive level

B3. Alignment Heuristics proposed by Pereira and Sousa (2005)

CATEGORY	MISALIGNMENT SYMPTOM
Alignment between Business Architecture and Information Architecture	All processes create, update and/or delete at least one entity
	All entity attributes are read by at least one process
	All processes assume the same entity description
Alignment between Business Architecture and Application Architecture	Each business process should be supported by at least one application system
	Business process tasks should be supported by a single application
	Critical business process should depend on scalable and available applications
	Each application system functionality should support at least one business process task
Alignment between Application Architecture and Information Architecture	An entity is managed by only one application
	If an information entity's ID is recovered, then the corresponding information entity should be created and deleted by the same computational process
	The data management should be automatic among the application systems
	Private entities should depend on restricted access applications
	Confidential entities should depend on restricted access applications
	The rate of updates should be correlated with rate of reads

B4. EA Alignment Heuristics proposed by Sousa et al. (2005)

CATEGORY	MISALIGNMENT SYMPTOM
Alignment between Business and Applications	Inserting the same data multiple times in different applications
	Logging in multiple times, once for each application they need to access
	Recovering from a failed operation across multiple systems, requiring careful human analyses to roll back to a coherent state
	Overcoming inappropriate application functionality, e.g. printing invoices one by one because applications do not have an interface for multiple printing
	Each business process should be supported by a minimum number of applications
	Business activities should be supported by a single application
	Critical business processes should be supported by scalable and highly available applications
	Critical business processes/activities should be supported by different applications than the noncritical business processes/activities
	Each application's functionality should support at least one business process activity
	Information required for critical processes should be also supported by scalable and highly available systems
	Business processes activities requiring on-line/batch support should be supported by applications running on different infrastructures, making easier the tuning of the systems for operating window
Alignment between Information and Application	Keeping multiple replicas of the same data coherent, because they are updated by multiple applications
	Assuring coherency from multiple transactions, because a single business process crosses multiple applications
	Gathering information from multiple systems and coding rules to produce a coherent view of the organisation's business information
	Transforming data structures when data migrates between applications
	An information entity is managed by only one application. This means that entities are identified, created and reused by a single application
	Information entities are created when identifiers are assigned to them, even if at that time no attributes are known
	Applications that manage information entities should provide means to make the entity information distributable across the organisation using agreed-on protocols and formats
	Exporting and distributing information entities across organisation applications should make use of a "data store", rather than a point-to-point Application integration
Alignment between Business and Information	All business processes activity create, update and/or delete at least one information entity
	All information entity attributes are read by at least one business process activity
	All information entities have an identifier understood by business people

(Continues)

B4. *(Continued)*

Category	Misalignment Symptom
	All information entities must have a mean of being transformed for presentation to appropriate audiences using enterprise-standard applications and tools
	All information entities must derive from known sources and must have business people responsible for its coherence, accuracy, relevance and quality control
	All information entities must be classified and named within the Information Architecture
	For each information entity, Business people should be responsible for assessing the usefulness and cost/benefits of information and sustain its continued use

B5. Misalignment Symptom Collection proposed by Carvalho and Sousa (2008)

Code	Symptom Classification Scheme Record
S.01	I am not aware of the organisation's mission
S.02	I am not aware of the organisation's strategy and goals
S.03	I do not know who the ultimate responsible for a business process is
S.04	I do not know with whom I should speak to obtain knowledge about business processes
S.05	I do not know what my responsibilities are
S.06	I do not know what the expectations about my work are
S.07	I do not know to whom I should report within the context of different activities
S.08	I am not aware of the process contribution towards the organisation goals
S.09	I am not aware of my contribution towards the organisation goals
S.10	I do not know with whom I should speak to obtain the semantics of informational entities
S.11	I do not know who the ultimate responsible for a business informational entity is
S.12	I find that same entity has different semantics according to the interlocutor
S.13	I find that different concepts and names are used to refer to same entity
S.14	I do not have the required information to support day-to-day activities
S.15	I do not have the required information to support decision-making
S.16	I find information outdated
S.17	I do not know with whom I should speak to obtain information and help about an application
S.18	I do not know who the ultimate responsible for an application is
S.19	I need to repeat the login in different applications
S.20	I spend time configuring and updating users' profiles in several applications
S.21	I need to develop and use end user computing applications
S.22	I cannot develop/innovate certain types of business and products
S.23	I spend time reintroducing the same information over different applications
S.24	I need to use different applications during the day to perform my business activities
S.25	I spend time executing manual validations that could be automatic
S.26	I need to repeat the same application task several times to perform a business activity
S.27	I do not understand how to use and interpret the same concept in different applications
S.28	I need to run queries on different applications to get a full picture of an entity
S.29	I find information consistency problems
S.30	I find information integrity problems
S.31	I spend time to correct data to ensure consistency between information replicas
S.32	I have no confidence in application's information

(Continues)

B5. *(Continued)*

CODE	SYMPTOM CLASSIFICATION SCHEME RECORD
S.33	I find information entities with required fields not filled
S.34	I spend time synchronising data between applications
S.35	I need to keep competencies on several different technologies, operating systems, and DBMS
S.36	I can't comply with the business level of service
S.37	I have frequent periods where applications are unavailable
S.38	I find that batch processes are not completed during the non-working period
S.39	I spend extra resources and costs with new developments facing information volume increase
S.40	I have found unprotected confidential information
S.41	I have found that users have access to information not required for their business activities

B6. Misalignment Etiology Collection proposed by Carvalho and Sousa (2008)

CODE	ETIOLOGY CLASSIFICATION SCHEME RECORD
E.01	Undefined organisational strategy and organisational goals
E.02	Undefined business process goals
E.03	Lack of relation between process goals and organisational goals
E.04	Undefined business roles
E.05	Undefined responsibilities
E.06	Undefined hierarchy or lines of reporting
E.07	Multiple hierarchy or lines of reporting
E.08	Insufficient business users training
E.09	Lack of data ownership
E.10	Poor IT planning and portfolio management
E.11	Insufficient IT resources
E.12	Lack of IT skills and competencies
E.13	Lack of data quality controls
E.14	Undefined business information requirements
E.15	Multiple applications managing the same information
E.16	Unavailable requirements at the application level
E.17	Wrong requirements implemented at the application level
E.18	Users managed differently in different applications
E.19	Lack of application interfaces
E.20	Undefined security requirements over the information entities
E.21	Undefined capacity and performance requirements
E.22	Under capacity infrastructure
E.23	Insufficient involvement of business users in systems developments
E.24	Undefined criteria to prioritise IT projects
E.25	Undefined business service levels
E.26	Lack of translation from business service levels to IT service levels
E.27	Lack or poor systems performance monitoring
E.28	Technological heterogeneity
E.29	Obsolete technological infrastructure
E.30	Incompatible platforms or technologies

Appendix C: List of TOGAF Artefacts

This appendix contains the entire list of TOGAF artefacts with brief description, artefact type categorisation and ADM phase assignment.

C1. List of TOGAF Artefacts (based on TOG, 2015)

ARTEFACT	BRIEF DESCRIPTION	ARTEFACT TYPE	TOGAF ADM PHASE
Principles Catalogue	Captures principles of the business and architecture principles that describe what a ‘‘good’’ solution or architecture should look like	Catalogue	Preliminary
Stakeholder Map Matrix	Identifies the stakeholders for the architecture engagement, their influence, key questions, issues, or concerns that must be addressed by the architecture framework	Matrix	Vision
Value Chain Diagram	A high-level orientation view of an enterprise and how it interacts with the outside world; focuses on presentational impact	Diagram	Vision
Solution Concept Diagram	A high-level orientation of the solution that is envisaged in order to meet the objectives of the architecture engagement; represents a ‘‘pencil sketch’’ of the expected solution at the outset of the engagement	Diagram	Vision
Organisation/ Actor Catalogue	Captures a definitive listing of all participants (in different organisation units) that interact with IT, including users and owners of IT systems	Catalogue	Business Architecture
Driver/Goal/ Objective Catalogue	Provides a cross-organisational reference of how an organisation meets its drivers in practical terms through goals, objectives, and (optionally) measures	Catalogue	Business Architecture
Role Catalogue	Provides a listing of all authorisation levels or zones within an enterprise	Catalogue	Business Architecture
Business Service/ Function Catalogue	Provides a functional decomposition in a form that can be filtered, reported on, and queried, as a supplement to graphical Functional Decomposition diagrams	Catalogue	Business Architecture
Location Catalogue	A listing of all locations where an enterprise carries out business operations or houses architecturally relevant assets, such as data centres or end-user computing equipment	Catalogue	Business Architecture
Process/Event/ Control/ Product Catalogue	A hierarchy of processes, events that trigger processes, outputs from processes, and controls applied to the execution of processes	Catalogue	Business Architecture
Contract/ Measure Catalogue	A listing of all agreed service contracts and (optionally) the measures attached to those contracts	Catalogue	Business Architecture
Business Interaction Matrix	Depicts the relationship interactions between organisations and business functions across the enterprise	Matrix	Business Architecture

(Continues)

C1. *(Continued)*

ARTEFACT	BRIEF DESCRIPTION	ARTEFACT TYPE	TOGAF ADM PHASE
Actor/Role Matrix	Shows which actors perform which roles, supporting definition of security and skills requirements	Matrix	Business Architecture
Business Footprint Diagram	Describes the links between business goals, organisational units, business functions, and services, and maps these functions to the technical components delivering the required capability	Diagram	Business Architecture
Business Service/ Information Diagram	Shows the information needed to support one or more business services	Diagram	Business Architecture
Functional Decomposition Diagram	Shows on a single page the capabilities of an organisation that are relevant to the consideration of an architecture	Diagram	Business Architecture
Product Lifecycle Diagram	Assists in understanding the lifecycles of key entities within the enterprise	Diagram	Business Architecture
Goal/Objective /Service Diagram	Defines the ways in which a service contributes to the achievement of a business vision or strategy	Diagram	Business Architecture
Business Use-Case Diagram	Displays the relationships between consumers and providers of business services	Diagram	Business Architecture
Organisation Decomposition Diagram	Describes the links between actor, roles, and location within an organisation tree	Diagram	Business Architecture
Process Flow Diagram	Depicts all models and mappings related to the process metamodel entity	Diagram	Business Architecture
Event Diagram	Depicts the relationship between events and processes	Diagram	Business Architecture
Data Entity/ Data Component Catalogue	A list of all the data use across the enterprise, including data entities and also the data components where data entities are stored	Catalogue	Data Architecture
Data Entity/ Business Function Matrix	Depicts the relationship between data entities and business functions within the enterprise	Matrix	Data Architecture
Application/ Data Matrix	Depicts the relationship between applications (i.e., application components) and the data entities that are accessed and updated by them	Matrix	Data Architecture
Conceptual Data Diagram	Depicts the relationships between critical data entities within the enterprise	Diagram	Data Architecture
Logical Data Diagram	Shows logical views of the relationships between critical data entities within the enterprise	Diagram	Data Architecture

(Continues)

C1. *(Continued)*

Artefact	Brief Description	Artefact Type	TOGAF ADM Phase
Data Dissemination Diagram	Shows the relationship between data entity, business service, and application components	Diagram	Data Architecture
Data Security Diagram	Depicts which actor (person, organisation, or system) can access which enterprise data	Diagram	Data Architecture
Data Migration Diagram	Shows the flow of data from the source to the target applications	Diagram	Data Architecture
Data Lifecycle Diagram	Depicts the way of managing business data throughout its lifecycle from conception until disposal within the constraints of the business process	Diagram	Data Architecture
Application Portfolio Catalogue	A list of all the applications in the enterprise	Catalogue	Application Architecture
Interface Catalogue	Scopes and documents the interfaces between applications to enable the overall dependencies between applications to be scoped as early as possible	Catalogue	Application Architecture
Application/ Organisation Matrix	Depicts the relationship between applications and organisational units within the enterprise	Matrix	Application Architecture
Role/ Application Matrix	Depicts the relationship between applications and the business roles that use them within the enterprise	Matrix	Application Architecture
Application/ Function Matrix	Depicts the relationship between applications and business functions within the enterprise	Matrix	Application Architecture
Application Interaction Matrix	Depicts communications relationships between applications	Matrix	Application Architecture
Application Communication Diagram	Depicts all models and mappings related to communication between applications in the metamodel entity	Diagram	Application Architecture
Application and User Location Diagram	Shows the geographical distribution of applications	Diagram	Application Architecture
Application Use-Case Diagram	Displays the relationships between consumers and providers of application services	Diagram	Application Architecture
Enterprise Manageability Diagram	Shows how one or more applications interact with application and technology components that support operational management of a solution	Diagram	Application Architecture
Process/ Application Realisation Diagram	Depicts the sequence of events when multiple applications are involved in executing a business process	Diagram	Application Architecture

(Continues)

C1. *(Continued)*

Artefact	Brief Description	Artefact Type	TOGAF ADM Phase
Software Engineering Diagram	Breaks applications into packages, modules, services, and operations from a development perspective	Diagram	Application Architecture
Application Migration Diagram	Identifies application migration from baseline to target application components	Diagram	Application Architecture
Software Distribution Diagram	Shows how application software is structured and distributed across the estate	Diagram	Application Architecture
Technology Standards Catalogue	Documents the agreed standards for technology across the enterprise covering technologies, and versions, the technology lifecycles, and the refresh cycles for the technology	Catalogue	Technology Architecture
Technology Portfolio Catalogue	A list of all the technology in use across the enterprise, including hardware, infrastructure software, and application software	Catalogue	Technology Architecture
Application/ Technology Matrix	Documents the mapping of applications to technology platform	Matrix	Technology Architecture
Environments and Locations Diagram	Depicts which locations host which applications, identifies what technologies and/or applications are used at which locations, and finally identifies the locations from which business users typically interact with the applications	Diagram	Technology Architecture
Platform Decomposition Diagram	Depicts the technology platform that supports the operations of the Information Systems Architecture	Diagram	Technology Architecture
Processing Diagram	Focuses on deployable units of code/configuration and how these are deployed onto the technology platform	Diagram	Technology Architecture
Networked Computing/ Hardware Diagram	Documents the mapping between logical applications and the technology components (e.g., server) that support the application both in the development and production environments	Diagram	Technology Architecture
Communications Engineering Diagram	Describes the means of communication — the method of sending and receiving information — between these assets in the Technology Architecture; insofar as the selection of package solutions in the preceding architectures put specific requirements on the communications between the applications	Diagram	Technology Architecture
Project Context Diagram	Shows the scope of a work package to be implemented as a part of a broader transformation roadmap	Diagram	Opportunities and Solutions

(Continues)

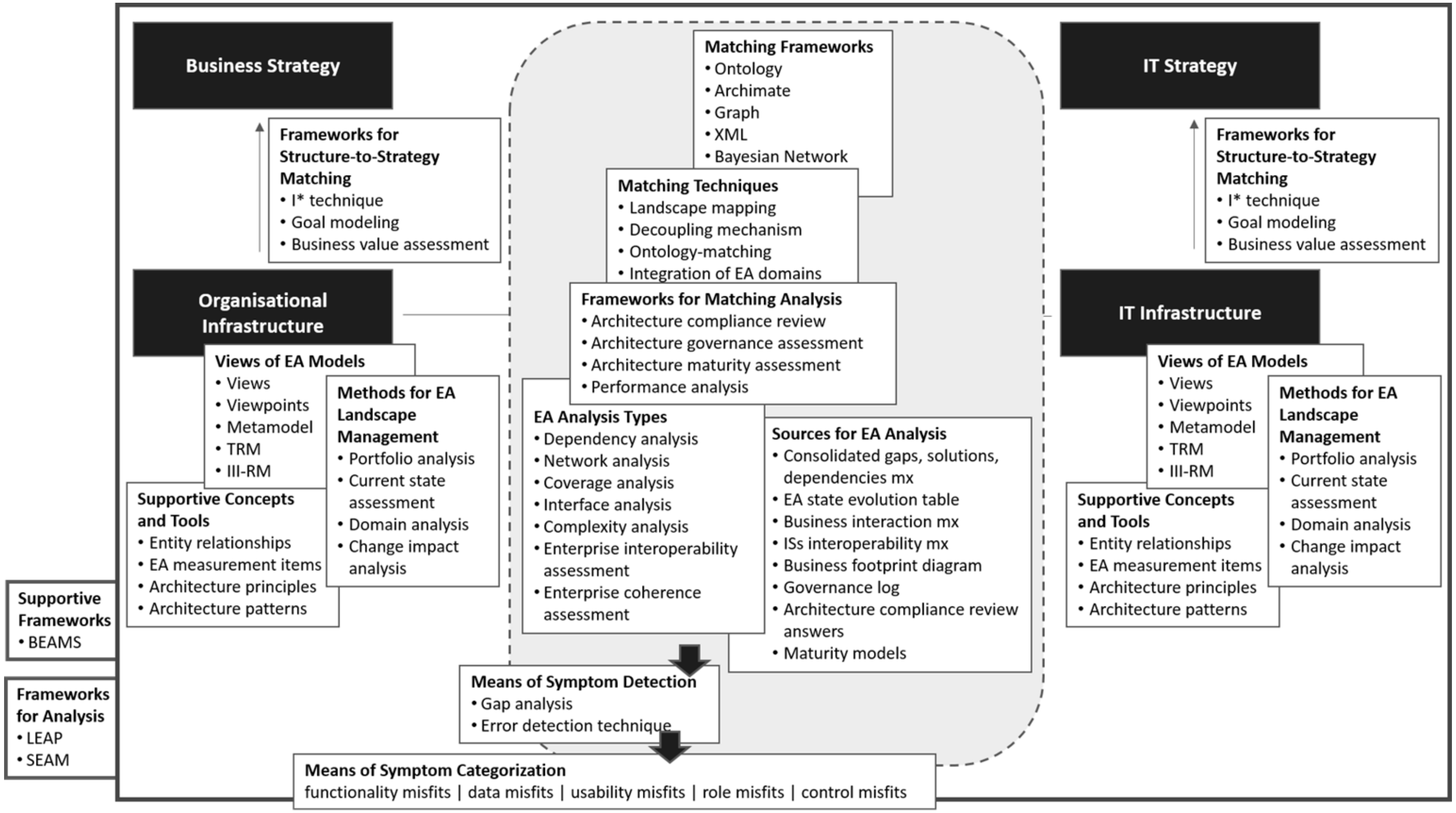
C1. *(Continued)*

Artefact	Brief Description	Artefact Type	TOGAF ADM Phase
Benefits Diagram	Shows opportunities identified in an architecture definition classified according to their relative size, benefit, and complexity	Diagram	Opportunities and Solutions
Requirements Catalogue	Captures things that the enterprise needs to do to meet its objectives	Catalogue	Requirements Management

Appendix D: Preliminary Results on SAM-based Misalignment Assessment

This appendix contains a composition of concepts for a SAM-based misalignment assessment framework using alignment domain matches.

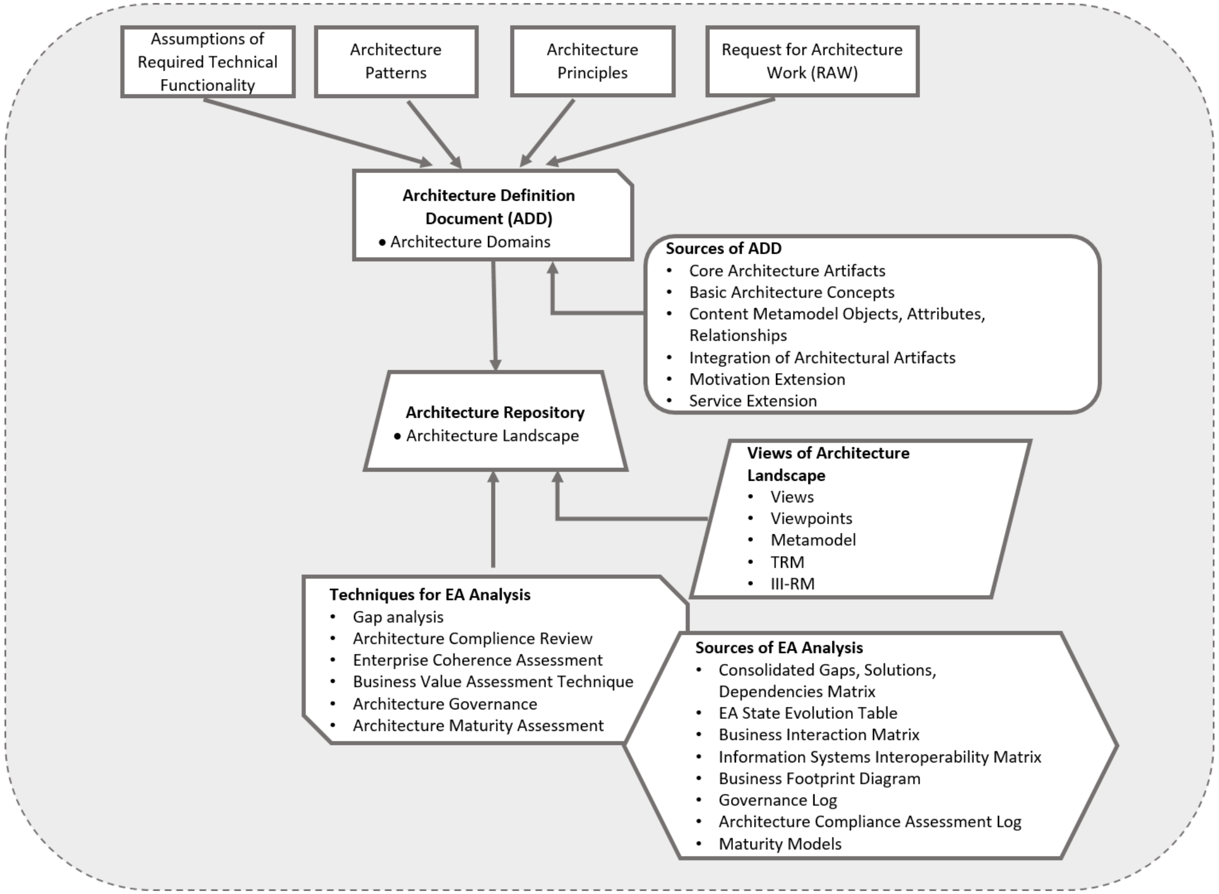
D1. Preliminary Results on SAM-based Misalignment Assessment



Appendix E: Preliminary Results on TOGAF-based Misalignment Assessment

This appendix contains a composition of TOGAF-based concepts for misalignment assessment.

E1. Preliminary Results on TOGAF-based Misalignment Assessment



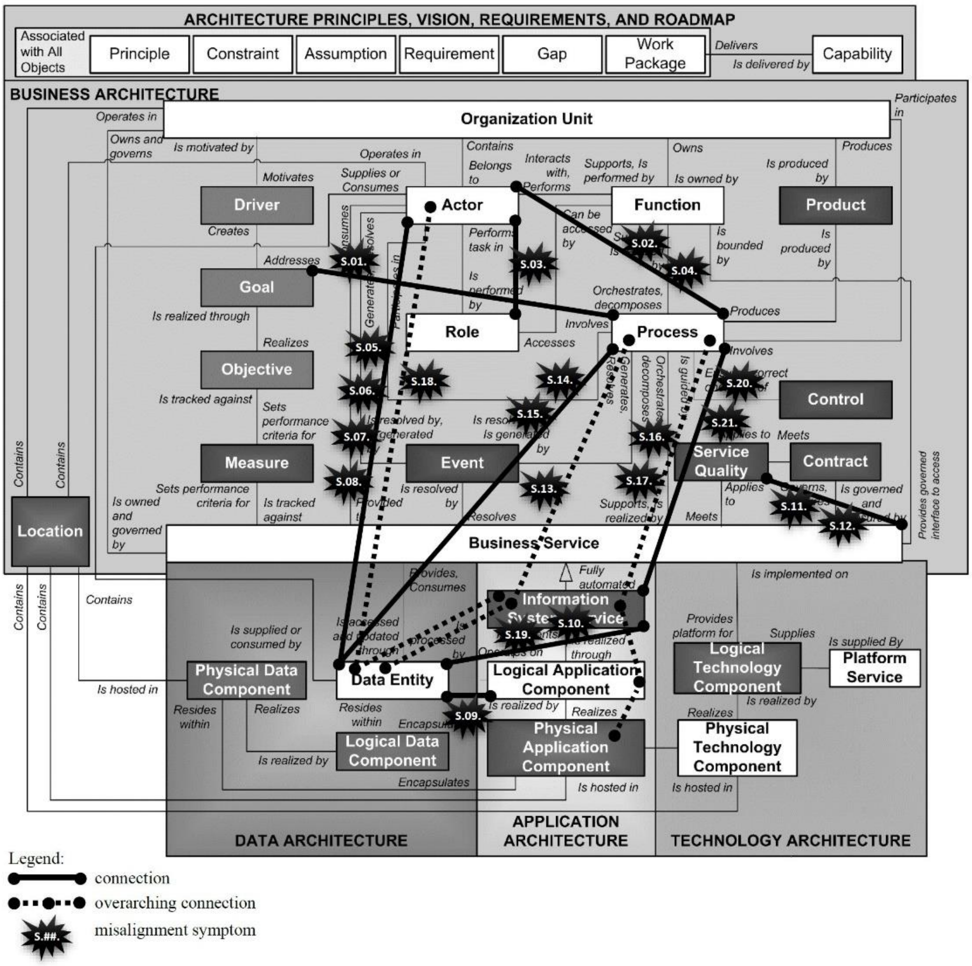
Appendix F: Preliminary Results on Symptom Localisation

This appendix contains a thought experiment for TOGAF-based misalignment symptom localisation. In this preliminary result, misalignment symptoms are located on the TOGAF metamodel.

F1. Misalignment Symptom Collection (Carvalho and Sousa, 2008; Pereira and Sousa, 2005; Sousa et al., 2004)

Code	Misalignment Symptom
S.01	Unknown process contribution towards organisation goals
S.02	Unknown contribution towards organisation goals
S.03	Unknown responsibilities
S.04	The ultimate responsible for a business process is not known
S.05	Lack of required information to support decision making
S.06	Lack of required information to support day-to-day activities
S.07	Outdated information is found
S.08	Information entities do not have a business actor responsible for its coherency and accuracy
S.09	Time is spent on synchronising data between applications
S.10	Non-automatic data management among application systems
S.11	Frequent periods are found where applications are unavailable
S.12	Compliance problems with required business level of services due to low application performance
S.13	Information required for critical processes are not supported by scalable and highly available systems
S.14	There are processes that do not create, update and/or delete at least one entity
S.15	There are entity attributes that are not read by at least one process
S.16	There are business processes that are not supported by at least one application system
S.17	There are application system functionalities that do not support at least one business process activity
S.18	Time is spent on reintroducing the same information over different applications
S.19	An information entity is managed by multiple applications
S.20	Business process is supported by multiple applications
S.21	Critical business processes do not depend on scalable and available applications
S.22	The rate of updates are not correlated with rate of reads
S.23	Unprotected confidential information are found
S.24	Confidential/private entities do not depend on restricted access applications
S.25	Problems with information integrity
S.26	Unknown reporting lines
S.27	Repeated logins in different applications
S.28	Information entities do not derive from known sources

F2. Locating Misalignment Symptoms on TOGAF Metamodel (based on TOG, 2015)



Appendix G: Preliminary Results on Perspective-based Symptom Analysis

In this appendix, preliminary results are given on alignment perspective-based symptom detection and analysis.

G1. Analysis of Strategy Execution Perspective

Perspective Component	Misalignment Symptom	Containing EA Artefact	Related EA Analysis Type
P.1.1 Business Strategy and Business Structure matching	S.01 Undefined organisational mission, strategy, and goals	AF.01 Driver/Goal/Objective Catalogue AF.06 Business Footprint Diagram AF.08 Goal/Objective/Service Diagram	A.03 Coverage analysis
	S.02 Undefined business process goals, business process owners	AF.10 Organisational Decomposition Diagram AF.01 Driver/Goal/Objective Catalogue AF.02 Role Catalogue Actor/Role Matrix AF.06 Business Footprint Diagram AF.08 Goal/Objective/Service Diagram AF.09 Business Use-Case Diagram	A.03 Coverage analysis
	S.03 Lack of relation between process goals and organisational goals	AF.01 Driver/Goal/Objective Catalogue AF.06 Business Footprint Diagram AF.08 Goal/Objective/Service Diagram	A.01 Dependency analysis, A.02 Network analysis
	S.04 Undefined business roles or responsibilities	AF.10 Organisational Decomposition Diagram AF.02 Role Catalogue Actor/Role Matrix AF.09 Business Use-Case Diagram	A.03 Coverage analysis
	S.05 Undefined or multiple hierarchy or lines of reporting	AF.10 Organisational Decomposition Diagram AF.02 Role Catalogue AF.05 Actor/Role Matrix AF.09 Business Use-Case Diagram	A.01 Dependency analysis, A.06 Enterprise interoperability assessment
P.1.2 Business Structure and IT Structure matching	S.06 Application functionality does not support at least one business process activity	AF.15 Application Portfolio Catalogue AF.06 Application/Function Matrix AF.20 Process/Application Realisation Diagram	A.01 Dependency analysis, A.03 Coverage analysis, A.08 Heterogeneity analysis
	S.07 Business process task supported by more than one application	AF.11 Process Flow Diagram AF.15 Application Portfolio Catalogue AF.06 Application/Function Matrix AF.20 Process/Application Realisation Diagram	A.01 Dependency analysis, A.03 Coverage analysis, A.08 Heterogeneity analysis

(Continues)

G1. *(Continued)*

PERSPECTIVE COMPONENT	MISALIGNMENT SYMPTOM	CONTAINING EA ARTEFACT	RELATED EA ANALYSIS TYPE
	S.08 Critical business process does not depend on scalable and available applications	AF. 15 Application Portfolio Catalogue AF.06 Application/Function Matrix AF.19 Application Use-Case Diagram AF.20 Process/Application Realisation Diagram AF.23 Application/Technology Matrix	A.01 Dependency analysis, A.03 Coverage analysis
	S.09 Inappropriate application functionality	AF.15 Application Portfolio Catalogue AF.06 Application/Function Matrix AF.17 Application Interaction Matrix AF.19 Application Use-Case Diagram AF.20 Process/Application Realisation Diagram	A.03 Coverage analysis, A.07 Enterprise coherence assessment
	S.22 Undefined business service levels	AF.04 Contract/Measure Catalogue	A.03 Coverage analysis, A.07 Enterprise coherence assessment

G2. Analysis of Technology Transformation Perspective

PERSPECTIVE COMPONENT	MISALIGNMENT SYMPTOM	CONTAINING EA ARTEFACT	RELATED EA ANALYSIS TYPE
P.2.1 Business Strategy and IT Strategy matching	S.10 Insufficient IT resources	AF.21 Software Distribution Diagram AF.24 Platform Decomposition Diagram	A.05 Complexity analysis, A.08 Heterogeneity analysis
	S.11 Lack of IT skills and competencies	AF.02 Role Catalogue AF.10 Organisation Decomposition Diagram	A.02 Network analysis, A.03 Coverage analysis, A.05 Complexity analysis
	S.12 Lack of skills to develop or innovate certain types of products	AF.03 Business Service/Function Catalogue AF.07 Functional Decomposition Diagram	A.03 Coverage analysis
	S.13 Poor IT planning and portfolio management	AF.07 Functional Decomposition Diagram AF.15 Application Portfolio Catalogue	A.03 Coverage analysis, A.05 Complexity analysis, A.08 Heterogeneity analysis
P.2.2 IT Strategy and	S.13 Poor IT planning and portfolio management	AF.07 Functional Decomposition Diagram AF.15 Application Portfolio Catalogue	A.03 Coverage analysis,

(Continues)

G2. *(Continued)*

Perspective Component	Misalignment Symptom	Containing EA Artefact	Related EA Analysis Type
IT Structure matching			A.05 Complexity analysis, A.08 Heterogeneity analysis
	S.10 Insufficient IT resources	AF.21 Software Distribution Diagram AF.24 Platform Decomposition Diagram	A.05 Complexity analysis, A.08 Heterogeneity analysis
	S.14 Under capacity infrastructure	AF.21 Software Distribution Diagram AF.24 Platform Decomposition Diagram	A.02 Network analysis, A.03 Coverage analysis
	S.15 Lack or poor systems performance monitoring	AF.25 Processing Diagram	A.02 Network analysis, A.05 Complexity analysis, A.07 Enterprise coherence assessment
	S.16 Out of date technological infrastructure	AF.22 Technology Portfolio Catalogue AF.24 Platform Decomposition Diagram AF.25 Processing Diagram	A.03 Coverage analysis, A.04 Interface analysis, A.05 Complexity analysis, A.06 Enterprise interoperability assessment, A.08 Heterogeneity analysis

G3. Analysis of Competitive Potential Perspective

Perspective Component	Misalignment Symptom	Containing EA Artefact	Related EA Analysis Type
P.3.1 IT Strategy and Business Strategy matching	S.12 Lack of skills to develop or innovate certain types of business and products	AF.03 Business Service/Function Catalogue AF.07 Functional Decomposition Diagram	A.03 Coverage analysis

(Continues)

G3. *(Continued)*

Perspective Component	Misalignment Symptom	Containing EA Artefact	Related EA Analysis Type
	S.13 Poor IT planning and portfolio management	AF.07 Functional Decomposition Diagram AF.15 Application Portfolio Catalogue	A.03 Coverage analysis, A.05 Complexity analysis, A.08 Heterogeneity analysis
P.3.2 Business Strategy and Business Structure matching	S.01 Undefined organisational mission, strategy, and goals	AF.01 Driver/Goal/Objective Catalogue AF.06 Business Footprint Diagram AF.08 Goal/Objective/Service Diagram	A.03 Coverage analysis
	S.02 Undefined business process goals, business process owners	AF.10 Organisational Decomposition Diagram AF.01 Driver/Goal/Objective Catalogue AF.02 Role Catalogue AF.05 Actor/Role Matrix AF.06 Business Footprint Diagram AF.08 Goal/Objective/Service Diagram AF.09 Business Use-Case Diagram	A.03 Coverage analysis
	S.03 Lack of relation between process goals and organisational goals	AF.01 Driver/Goal/Objective Catalogue AF.06 Business Footprint Diagram AF.08 Goal/Objective/Service Diagram	A.01 Dependency analysis, A.02 Network analysis
	S.04 Undefined business roles or responsibilities	AF.10 Organisational Decomposition Diagram AF.02 Role Catalogue AF.05 Actor/Role Matrix AF.09 Business Use-Case Diagram	A.03 Coverage analysis
	S.05 Undefined or multiple hierarchy or lines of reporting	AF.10 Organisational Decomposition Diagram AF.02 Role Catalogue AF.05 Actor/Role Matrix AF.09 Business Use-Case Diagram AF.10 Organisation Decomposition Diagram	A.01 Dependency analysis, A.06 Enterprise interoperability assessment

G4. Analysis of Service Level Perspective

Perspective Component	Misalignment Symptom	Containing EA Artefact	Related EA Analysis Type
P.4.1 IT Strategy and IT Structure matching	S.13 Poor IT planning and portfolio management	AF.07 Functional Decomposition Diagram AF.15 Application Portfolio Catalogue	A.03 Coverage analysis, A.05 Complexity analysis, A.08 Heterogeneity analysis
	S.15 Lack or poor systems performance monitoring	AF.25 Processing Diagram	A.02 Network analysis, A.05 Complexity analysis, A.07 Enterprise coherence assessment
	S.18 Technological heterogeneity	AF.22 Technology Portfolio Catalogue AF.23 Application/Technology Matrix AF.24 Platform Decomposition Diagram AF.25 Processing Diagram	A.08 Heterogeneity analysis
	S.19 Incompatible platforms or technologies	AF.22 Technology Portfolio Catalogue AF.23 Application/Technology Matrix AF.24 Platform Decomposition Diagram AF.25 Processing Diagram	A.04 Interface analysis, A.06 Enterprise interoperability assessment
	S.14 Under capacity infrastructure	AF.21 Software Distribution Diagram AF.24 Platform Decomposition Diagram AF.25 Processing Diagram	A.02 Network analysis, A.03 Coverage analysis
	S.16 Out of date technological infrastructure	AF.22 Technology Portfolio Catalogue AF.24 Platform Decomposition Diagram AF.25 Processing Diagram	A.03 Coverage analysis, A.04 Interface analysis, A.05 Complexity analysis, A.06 Enterprise interoperability assessment, A.08 Heterogeneity analysis
P.4.2 IT Structure and Business Structure matching	S.20 Frequent periods while applications are unavailable	AF.18 Application and User Location Diagram AF.19 Application Use-Case Diagram AF.23 Application/Technology Matrix AF.25 Processing Diagram	A.05 Complexity analysis, A.07 Enterprise coherence assessment

(Continues)

G4. *(Continued)*

Perspective Component	Misalignment Symptom	Containing EA Artefact	Related EA Analysis Type
	S.21 Information consistency or integrity problems	AF.12 Data Entity/Data Component Catalogue AF.13 Data Entity/Business Function Matrix AF.14 Data Migration Diagram	A.01 Dependency analysis, A.06 Enterprise interoperability assessment, A.07 Enterprise coherence assessment, A.08 Heterogeneity analysis
	S.08 Critical business processes are not supported by scalable and highly available applications	AF.15 Application Portfolio Catalogue AF.16 Application/Function Matrix AF.19 Application Use-Case Diagram AF.20 Process/Application Realisation Diagram AF.23 Application/Technology Matrix	A.01 Dependency analysis, A.03 Coverage analysis
	S.22 Undefined business service levels	AF.04 Contract/Measure Catalogue	A.03 Coverage analysis, A.07 Enterprise coherence assessment

Appendix H: Schematic Structure of AML Exports

This appendix contains the general structure of ARIS-based XML (AML) exports, which are generated from EA models.

H1. Schematic Structure of AML Exports

```
<?xml version="1.0" encoding="UTF-8"?>
<AML>
       <Header-Info/>
       <Database>
              <AttrDef>
                     <AttrValue></AttrValue>
              </AttrDef>
       </Database>
       <FontStyleSheet>
              <AttrDef>
                     <AttrValue></AttrValue>
              </AttrDef>
              <FontNode/>
       </FontStyleSheet>
       <FFTextDef>
              <AttrDef>
                     <AttrValue></AttrValue>
              </AttrDef>
       </FFTextDef>
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       </OLEDef>
       <Group>
              <ObjDef>
                     <AttrDef>
                            <AttrValue></AttrValue>
                     </AttrDef>
                     <CxnDef></CxnDef>
              </ObjDef>
              <Model>
                     <Lane></Lane>
                     <AttrDef>
                            <AttrValue></AttrValue>
                     </AttrDef>
                     <ObjOcc>
                            <CxnOcc>
                                   <AttrOcc></AttrOcc>
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                     </ObjOcc>
                     <FFTextOcc>
                            <Position/>
                     </FFTextOcc>
                     <GfxObj></GfxObj>
                     <OLEOcc>
                            <Position/>
                            <Size/>
                     </OLEOcc>
                     <Union></Union>
              </Model>
       </Group>
</AML>
```

Appendix I: Document Type Definition (DTD) for ARIS XML

This appendix contains the document type definition (DTD) for ARIS export, i.e. for ARIS-based XML (AML) documents.

I1. Schematic Structure of AML Exports

```
<?xml version="1.0" encoding="UTF-8"?>
<!ELEMENT AML (Header-Info, Language+, Prefix*, Database?,
LDAPSettings?, User*, UserGroup*, FontStyleSheet*, FFTextDef*,
OLEDef*, Group, Delete*)>
<!ELEMENT Header-Info EMPTY>
<!ATTLIST Header-Info CreateTime NMTOKEN #IMPLIED CreateDate NMTOKEN
#IMPLIED DatabaseName CDATA #IMPLIED UserName CDATA #IMPLIED
ArisExeVersion (61 | 62 | 70 | 71 | 80 | 90 | 95 | 96 | 97) #REQUIRED>
<!ELEMENT Prefix (#PCDATA) >
<!ATTLIST Prefix Default (YES | NO) "NO">
<!ELEMENT Blob (#PCDATA)>
<!ELEMENT Flag (#PCDATA)>
<!ELEMENT GUID (#PCDATA)>
<!ELEMENT FilterGUID (#PCDATA)>
<!ELEMENT MasterGUID (#PCDATA)>
<!ELEMENT TypeGUID (#PCDATA)>
<!ELEMENT TemplateGUID (#PCDATA)>
<!ELEMENT SymbolGUID (#PCDATA)>
<!ELEMENT ExternalGUID (#PCDATA)>
<!ELEMENT Pen EMPTY>
<!ATTLIST Pen Color NMTOKEN #REQUIRED Style NMTOKEN #REQUIRED Width
NMTOKEN #REQUIRED>
<!ELEMENT Brush EMPTY>
<!ATTLIST Brush Color NMTOKEN #REQUIRED Style NMTOKEN #IMPLIED Hatch
NMTOKEN #IMPLIED Color2 NMTOKEN #IMPLIED BrushType (SOLID |
TRANSPARENT | GRADIENT_LEFT | GRADIENT_TOP |
GRADIENT_DIAGONAL_TOP_LEFT | GRADIENT_DIAGONAL_BOTTOM_LEFT) "SOLID">
<!ELEMENT Size EMPTY>
<!ATTLIST Size Size.dX NMTOKEN #REQUIRED Size.dY NMTOKEN #REQUIRED>
<!ELEMENT Position EMPTY>
<!ATTLIST Position Pos.X NMTOKEN #REQUIRED Pos.Y NMTOKEN #REQUIRED>
<!ELEMENT Database (AttrDef+)>
<!ELEMENT Language (LanguageName?, LogFont?)>
<!ATTLIST Language     Language.ID ID #IMPLIED LocaleId NMTOKEN
#REQUIRED Codepage CDATA #REQUIRED>
<!ELEMENT LanguageName (#PCDATA)>
<!ELEMENT LogFont EMPTY>
<!ATTLIST LogFont FaceName CDATA #REQUIRED Height NMTOKEN #REQUIRED
Width NMTOKEN #REQUIRED Escapement NMTOKEN #REQUIRED Orientation
NMTOKEN #REQUIRED Weight NMTOKEN #REQUIRED Italic (YES | NO) "NO"
      Underline (YES | NO) "NO" StrikeOut (YES | NO) "NO" CharSet
NMTOKEN #REQUIRED OutPrecision NMTOKEN #REQUIRED ClipPrecision NMTOKEN
#REQUIRED Quality NMTOKEN #REQUIRED PitchAndFamily NMTOKEN #REQUIRED
Color NMTOKEN #REQUIRED>
<!ELEMENT LDAPProperty EMPTY>
<!ATTLIST LDAPProperty key NMTOKEN #REQUIRED value CDATA #REQUIRED>
```

(Continues)

```
<!ELEMENT LDAPSettings (LDAPProperty*)>
<!ELEMENT User (GUID?, AttrDef*, FilterGUID*, Prefix?)>
<!ATTLIST User User.ID ID #REQUIRED Name CDATA #IMPLIED isSystem (true
| false) "false" Passwd NMTOKEN #IMPLIED External NMTOKEN #IMPLIED
ExternalID CDATA #IMPLIED>
<!ELEMENT UserGroup (GUID?, AttrDef*, FilterGUID*, Prefix?)>
<!ATTLIST UserGroup    UserGroup.ID ID #REQUIRED Name CDATA #IMPLIED
User.IdRefs IDREFS #IMPLIED ExternalIDs CDATA #IMPLIED>
<!ELEMENT FontStyleSheet (GUID?, AttrDef*, FontNode+)>
<!ATTLIST FontStyleSheet     FontSS.ID ID #REQUIRED>
<!ELEMENT FontNode EMPTY>
<!ATTLIST FontNode LocaleId NMTOKEN #REQUIRED FaceName CDATA #REQUIRED
Height NMTOKEN #REQUIRED Width NMTOKEN #REQUIRED Escapement NMTOKEN
#REQUIRED Orientation NMTOKEN #REQUIRED Weight NMTOKEN #REQUIRED
Italic (YES | NO) "NO" Underline (YES | NO) "NO" StrikeOut (YES | NO)
"NO" CharSet NMTOKEN #REQUIRED OutPrecision NMTOKEN #REQUIRED
ClipPrecision NMTOKEN #REQUIRED Quality NMTOKEN #REQUIRED
PitchAndFamily NMTOKEN #REQUIRED Color NMTOKEN #REQUIRED>
<!ELEMENT Link (GUID?)>
<!ATTLIST Link To.IdRef IDREF #REQUIRED TypeNum NMTOKEN #IMPLIED
LinkRules NMTOKEN #IMPLIED>
<!ELEMENT ExtCxnDef (GUID?, AttrDef*, ExtCxnDef*)>
<!ATTLIST ExtCxnDef    ExtCxnDef.ID ID #REQUIRED ExtCxnDef.Type
NMTOKEN #REQUIRED ToDef.IdRef IDREF #REQUIRED Reorg (DELETE|NODELETE)
"DELETE" LastUpdated CDATA #IMPLIED Creator CDATA #IMPLIED
CreationTimeStamp CDATA #IMPLIED LastModifier CDATA #IMPLIED
LastModificationTimeStamp CDATA #IMPLIED>
<!ELEMENT CxnDef (GUID?, AttrDef*, ExtCxnDef*, Link*)>
<!ATTLIST CxnDef CxnDef.ID ID #REQUIRED CxnDef.Type NMTOKEN #REQUIRED
ToObjDef.IdRef IDREF #REQUIRED LinkedModels.IdRefs IDREFS #IMPLIED
Reorg (DELETE|NODELETE) "DELETE" LastUpdated CDATA #IMPLIED
SourceOrderNum NMTOKEN #IMPLIED TargetOrderNum NMTOKEN #IMPLIED
Creator CDATA #IMPLIED CreationTimeStamp CDATA #IMPLIED LastModifier
CDATA #IMPLIED :astModificationTimeStamp CDATA #IMPLIED>
<!ELEMENT ObjDef (GUID?, MasterGUID?, SymbolGUID?, AttrDef*, CxnDef*,
ExtCxnDef*, Link*)>
<!ATTLIST ObjDef ObjDef.ID ID #REQUIRED TypeNum NMTOKEN #REQUIRED
LinkedModels.IdRefs IDREFS #IMPLIED ToCxnDefs.IdRefs IDREFS #IMPLIED
Reorg (DELETE|NODELETE) "DELETE" UmlManaged (NO | YES) "NO"
CentraSiteManaged (NO | YES) "NO" CentraSiteSyncRunning (NO | YES)
"NO" CentraSiteInProduction (NO | YES) "NO" SubTypeNum NMTOKEN
#IMPLIED SymbolNum NMTOKEN #IMPLIED LastUpdated CDATA #IMPLIED
CompositePosition NMTOKEN #IMPLIED CompositeType NMTOKEN #IMPLIED
Creator CDATA #IMPLIED CreationTimeStamp CDATA #IMPLIED LastModifier
CDATA #IMPLIED LastModificationTimeStamp CDATA #IMPLIED>
<!ELEMENT BackGroundColor EMPTY>
<!ATTLIST BackGroundColor Color NMTOKEN #REQUIRED>
<!ELEMENT Bold EMPTY>
<!ELEMENT Container EMPTY>
<!ELEMENT Enumeration EMPTY>
```

(Continues)

```
<!ATTLIST Enumeration Type (ORDERED|UNORDERED) #REQUIRED>
<!ELEMENT Font EMPTY>
<!ATTLIST Font Name CDATA #REQUIRED>
<!ELEMENT Italic EMPTY>
<!ELEMENT SoftHyphen EMPTY>
<!ELEMENT LineBreak EMPTY>
<!ELEMENT Paragraph EMPTY>
<!ATTLIST Paragraph Alignment (LEFT|CENTER|RIGHT|UNDEFINED)
"UNDEFINED" Indent NMTOKEN #IMPLIED>
<!ELEMENT PlainText EMPTY>
<!ATTLIST PlainText TextValue CDATA #REQUIRED>
<!ELEMENT SizeElement EMPTY>
<!ATTLIST SizeElement Value NMTOKEN #IMPLIED>
<!ELEMENT StrikeThrough EMPTY>
<!ELEMENT TextColor EMPTY>
<!ATTLIST TextColor Color NMTOKEN #REQUIRED>
<!ELEMENT Underline EMPTY>
<!ELEMENT StyledElement ( (BackGroundColor, StyledElement*) |(Bold,
StyledElement*)|(Container, StyledElement*)|(Enumeration,
StyledElement*)|(Font, StyledElement*)|(Italic,
StyledElement*)|SoftHyphen|LineBreak|(Paragraph,
StyledElement*)|PlainText|(SizeElement,
StyledElement*)|(StrikeThrough, StyledElement*)|(TextColor,
StyledElement*)|(Underline, StyledElement*))>
<!ELEMENT AttrValue ( #PCDATA | StyledElement )* >
<!ATTLIST AttrValue     LocaleId NMTOKEN #REQUIRED>
<!ELEMENT AttrDef (AttrValue+)>
<!ATTLIST AttrDef AttrDef.ID ID #IMPLIED AttrDef.Type NMTOKEN
#REQUIRED>
<!ELEMENT LabelOcc (Position, Size)>
<!ATTLIST LabelOcc TypeNum NMTOKEN #REQUIRED Rotation NMTOKEN
#REQUIRED FontSS.IdRef IDREF #IMPLIED>
<!ELEMENT PresentationOption EMPTY>
<!ATTLIST PresentationOption key NMTOKEN #REQUIRED value CDATA
#REQUIRED>
<!ELEMENT ObjOcc (SymbolGUID?, Pen?, Brush?, Position?, Size?,
ExternalGUID?, CxnOcc*, AttrOcc*, ExtCxnOcc*, LabelOcc*,
MultiDefCxnOcc*, PresentationOption*, Link*)>
<!ATTLIST ObjOcc ObjOcc.ID ID #REQUIRED ObjDef.IdRef IDREF #REQUIRED
ToCxnOccs.IdRefs IDREFS #IMPLIED Zorder NMTOKEN #IMPLIED SymbolNum
NMTOKEN #REQUIRED Active (YES | NO) "YES" Shadow (YES | NO) "NO"
Visible (YES | NO) "YES" Expanded (YES | NO) "NO" EmbeddingContainer
(YES | NO) "NO" Flags NMTOKEN #IMPLIED    Hints NMTOKEN #IMPLIED
SequenceNumber NMTOKEN #IMPLIED HasSymbolEffect NMTOKEN #IMPLIED
FontSS.IdRef IDREF #IMPLIED>
<!ELEMENT FFTextOcc (Position?,Size?)>
<!ATTLIST FFTextOcc FFTextOcc.ID ID #IMPLIED FFTextDef.IdRef IDREF
#REQUIRED FontSS.IdRef IDREF #IMPLIED SymbolFlag (TEXT | SYMBOL |
ATTRNAME | ATTRNAME_AND_SYMBOL | POSTIT | SYMBOL_AND_POSTIT |
ATTRNAME_AND_POSTIT | ATTRNAME_AND_SYMBOL_AND_POSTIT) #REQUIRED
```

```
      Alignment (LEFT | CENTER | RIGHT) "LEFT"    Zorder NMTOKEN
#IMPLIED>
<!ELEMENT AttrOcc (Size?)>
<!ATTLIST AttrOcc AttrOcc.ID ID #IMPLIED AttrTypeNum NMTOKEN #REQUIRED
Port (CENTER | N | NE | E | SE | S | SW | W | NW | NONE | UPPER_MIDDLE
| LOWER_MIDDLE | PORT_FREE) #REQUIRED OrderNum NMTOKEN #REQUIRED
Alignment (LEFT | CENTER | RIGHT) "LEFT" SymbolFlag (TEXT | SYMBOL |
WIDTH_ATTR_NAME | ATTR_NAME_AND_SYMBOL) #REQUIRED FontSS.IdRef IDREF
#IMPLIED OffsetX  NMTOKEN #IMPLIED OffsetY  NMTOKEN #IMPLIED
Rotation NMTOKEN #IMPLIED>
<!ELEMENT ExtCxnOcc (Pen?, Position*, AttrOcc*, ExtCxnOcc*)>
<!ATTLIST ExtCxnOcc ExtCxnOcc.ID ID #REQUIRED ExtCxnDef.IdRef IDREF
#REQUIRED ToOcc.IdRef IDREF #REQUIRED Zorder NMTOKEN #IMPLIED Active
(YES | NO) "YES" Diagonal (NO | YES) "NO" Visible (YES | NO) "YES"
Hints NMTOKEN #IMPLIED>
<!ELEMENT CxnOcc (Pen?, Position*, AttrOcc*, ExtCxnOcc*, Link*)>
<!ATTLIST CxnOcc CxnOcc.ID ID #REQUIRED CxnDef.IdRef IDREF #REQUIRED
ToObjOcc.IdRef IDREF #REQUIRED Zorder NMTOKEN #IMPLIED Active (YES |
NO) "YES" Diagonal (NO | YES) "NO" Visible (YES | NO) "YES" Embedding
(YES | NO) "NO" Hints NMTOKEN #IMPLIED SrcArrow NMTOKEN #IMPLIED
TgtArrow NMTOKEN #IMPLIED>
<!ELEMENT MultiDefCxnOcc (Pen?, Position*,AttrOcc*, LabelOcc*,
PresentationOption*, MultiDefCxnOcc*)>
<!ATTLIST MultiDefCxnOcc MultiDefCxnOcc.ID ID #REQUIRED Def.IdRef
IDREF #IMPLIED ToObj.IdRef IDREF #REQUIRED Participants.IdRefs IDREFS
#IMPLIED Zorder NMTOKEN #IMPLIED Hints NMTOKEN #IMPLIED SymbolNum
NMTOKEN #IMPLIED FontSS.IdRef IDREF #IMPLIED>
<!ELEMENT Lane (GUID?, Pen?, Brush?, AttrDef*)>
<!ATTLIST Lane Lane.ID ID #IMPLIED Lane.Type NMTOKEN #REQUIRED
Orientation (VERTICAL | HORIZONTAL) #REQUIRED StartBorder NMTOKEN
#REQUIRED EndBorder NMTOKEN #REQUIRED>
<!ELEMENT OLEDef (GUID?, Blob, Blob, AttrDef*)>
<!ATTLIST OLEDef OLEDef.ID ID #REQUIRED Link CDATA #IMPLIED
LastUpdated CDATA #IMPLIED Creator CDATA #IMPLIED CreationTimeStamp
CDATA #IMPLIED LastModifier CDATA #IMPLIED LastModificationTimeStamp
CDATA #IMPLIED>
<!ELEMENT OLEOcc (Position?, Size?)>
<!ATTLIST OLEOcc OLEOcc.ID ID #IMPLIED OLEDef.IdRef IDREF #REQUIRED
Zorder NMTOKEN #IMPLIED>
<!ELEMENT FFTextDef (GUID?, AttrDef+)>
<!ATTLIST FFTextDef FFTextDef.ID ID #REQUIRED IsModelAttr (TEXT |
MODELATTR) "TEXT" LastUpdated CDATA #IMPLIED Creator CDATA #IMPLIED
CreationTimeStamp CDATA #IMPLIED LastModifier CDATA #IMPLIED
LastModificationTimeStamp CDATA #IMPLIED>
<!ELEMENT Group (GUID?, MasterGUID?, SymbolGUID?, AttrDef*, Group*,
(ObjDef | Model)*, CxnDef*, Link*)>
<!ATTLIST Group Group.ID ID #REQUIRED TypeNum NMTOKEN #IMPLIED
LinkedModels.IdRefs IDREFS #IMPLIED ToCxnDefs.IdRefs IDREFS #IMPLIED
Reorg (DELETE|NODELETE) "DELETE"    SubTypeNum NMTOKEN #IMPLIED
SymbolNum NMTOKEN #IMPLIED LastUpdated CDATA #IMPLIED
```

```
CompositePosition NMTOKEN #IMPLIED CompositeType NMTOKEN #IMPLIED
Creator CDATA #IMPLIED CreationTimeStamp CDATA #IMPLIED LastModifier
CDATA #IMPLIED LastModificationTimeStamp CDATA #IMPLIED>
<!ELEMENT Polygon (Position*)>
<!ATTLIST Polygon    FillStatus (FILLED | TRANSPARENT) "TRANSPARENT">
<!ELEMENT RoundedRectangle (Position)>
<!ATTLIST RoundedRectangle    Shaded (YES | NO) "NO">
<!ELEMENT GfxObj (Pen?, Brush?, Position?, Size?, (Polygon |
RoundedRectangle))>
<!ATTLIST GfxObj GfxObj.ID ID #IMPLIED Zorder NMTOKEN #IMPLIED
HasSymbolEffect NMTOKEN #IMPLIED>
<!ELEMENT Union (Union*)>
<!ATTLIST Union OLEObjOccs.IdRefs IDREFS #IMPLIED ObjOccs.IdRefs
IDREFS #IMPLIED Gfxs.IdRefs IDREFS #IMPLIED TextOccs.IdRefs IDREFS
#IMPLIED Zorder NMTOKEN #IMPLIED Flags NMTOKEN #IMPLIED>
<!ELEMENT Model (Flag?, GUID?, MasterGUID?, TypeGUID?, TemplateGUID?,
Position?, Lane*, AttrDef*, ObjOcc*, FFTextOcc*, GfxObj*, OLEOcc*,
Union*, Link*)>
<!ATTLIST Model Model.ID ID #REQUIRED Model.Type NMTOKEN #REQUIRED
AttrHandling (OVERLAP | RESIZESYM | BREAKATTR | SHORTENATTR) #IMPLIED
CxnMode (ONLYVERTICAL | ANGULAR) #IMPLIED GridUse (NO | YES) #IMPLIED
GridSize NMTOKEN #IMPLIED Scale NMTOKEN #IMPLIED PrintScale NMTOKEN
#IMPLIED BackColor NMTOKEN #IMPLIED CurveRadius  NMTOKEN #IMPLIED
ArcRadius  NMTOKEN #IMPLIED LastUpdated CDATA #IMPLIED Creator CDATA
#IMPLIED CreationTimeStamp CDATA #IMPLIED LastModifier CDATA #IMPLIED
LastModificationTimeStamp CDATA #IMPLIED FixedVerticalLane IDREF
#IMPLIED FixedHorizontalLane IDREF #IMPLIED>
<!ELEMENT Delete (#PCDATA)>
<!ATTLIST Delete Type (GROUP|MODEL|OBJDEF|USER|USERGROUP|CXNDEF)
#REQUIRED>
```

Appendix J: Basic Elements of the Schematron Query Language

This appendix contains the terms and definitions as well as the core and ancillary elements of the Schematron Query Language. *Table J2* also contains the corresponding attributes for core and ancillary elements.

J1. Terms and Definitions (based on ISO Schematron, 2016)

TERM	DESCRIPTION
Abstract Pattern	A pattern in a rule that has been parameterised to enable reuse
Abstract Rule	A collection of assertions which can be included in other rules but which does not fire itself
Active Pattern	A pattern belonging to the active phase
Active Phase	One particular phase, whose patterns are used for validation
Assertion	A natural-language assertion with corresponding assertion test and ancillary attributes: assertions are marked up with assert and report elements
Assertion Test	An assertion modeled or implemented by a Boolean query; an assertion test "succeeds" or "fails"
Correct Schema	The schema that satisfies all the requirements of this part of ISO/IEC 19757
Diagnostic	Named natural language statements providing information to end-users of validators concerning the expected and actual values together with repair hints
Elaborated Rule Context Expression	A single rule context expression which explicitly disallows items selected by lexically previous rule contexts in the same pattern
Good Schema	A correct schema with queries which terminate and do not add constraints to those of the natural language assertions. Note: It may not be possible to compute that a schema is good
Implementation	An implementation of a Schematron validator
Name	A token with no whitespace characters
Natural-language Assertion	A natural-language statement expressing some part of a pattern; a natural-language assertion is "met" or "unmet"
Pattern	A named structure in instances specified in a schema by a lexically ordered collection of rules
Phase	A named, unordered collection of patterns; patterns may belong to more than one phase; two names, #ALL, and #DEFAULT, are reserved with particular meanings
Progressive Validation	The validation of constraints in stages determined or grouped to some extent by the schema author rather than, for example, entirely determined by document order
Query Language Binding	A named set, specified in a document called a Query Language Binding, of the languages and conventions used for assertion tests, rule-context expressions and so on, by a particular Schematron implementation. Schematron is defined as a framework, with a default query language binding, but other query language bindings are possible
Rule	Unordered collection of assertions with a rule context expression and ancillary attributes
Rule Context	A selection of elements; a rule is said to fire when an information item matches its query

(Continues)

J1. *(Continued)*

TERM	DESCRIPTION
Rule-context Expression	A query to specify subjects; a rule context is said to match an information item when that information item has not been matched by any lexically-previous rule context expressions in the same pattern and the information item is one of the information items that the query would specify
Schema	Specification of a set of XML documents
Subject	A particular information item which corresponds to the object of interest of the natural language assertions and typically is matched by the context expression of a rule
Valid with Respect to a Schema	Member of the set of XML documents described by the schema: an instance document is valid if no assertion tests in fired rules of active patterns fail
Abstract Pattern	A constant value, evaluated within the parent schema, phase, pattern or rule and scoped within the parent schema, phase, pattern or rule

J2. Schematron Elements (based on ISO Schematron, 2016)

ELEMENT TYPE	ELEMENT	ATTRIBUTES
Core Element	active	pattern
	assert	test | diagnostics | icon | see | fpi | flag | role | subject
	extends	rule
	include	href
	let	name | value
	name	path
	ns	prefix | uri
	param	name | value
	pattern	id | is-a | abstract | icon | see | fpi
	phase	id | icon | see | fpi
	report	test | diagnostics | icon | see | fpi | flag | role | subject
	rule	context | icon | see | fpi | flag | role | subject | abstract
	schema	schemaVersion | queryBinding | defaultPhase | icon | see | fpi
	value-of	select
Ancillary Element	diagnostic	xml:lang | diagnostics
	diagnostics	
	dir	value | ltr | rtl
	emph	
	p	class
	span	class
	title	

Appendix K: Main XPath Operators for Schematron Queries

This appendix contains the main operators for developing Schematron-based queries.

K1. Main XPath Operators (XPath, 2017)

EXPRESSION	DESCRIPTION
nodename	Selects all nodes with the name "*nodename*"
/	Selects from the root node
//	Selects nodes in the document from the current node that matches the selection no matter where they are
.	Selects the current node
..	Selects the parent of the current node
@	Selects attributes
bookstore	Selects all nodes with the name "bookstore"
/bookstore	Selects the root element bookstore
bookstore/book	Selects all book elements that are children of bookstore
//book	Selects all book elements no matter where they are in the document
bookstore//book	Selects all book elements that are descendant of the bookstore element, no matter where they are under the bookstore element
//@lang	Selects all attributes that are named lang
/bookstore/book[1]	Selects the first book element that is the child of the bookstore element.
/bookstore/book [last()]	Selects the last book element that is the child of the bookstore element
/bookstore/book [last()-1]	Selects the last but one book element that is the child of the bookstore element
/bookstore/book [position()<3]	Selects the first two book elements that are children of the bookstore element
//title[@lang]	Selects all the title elements that have an attribute named lang
//title[@lang='en']	Selects all the title elements that have a "lang" attribute with a value of "en"
/bookstore/book [price>35.00]	Selects all the book elements of the bookstore element that have a price element with a value greater than 35.00
/bookstore/book [price>35.00]/title	Selects all the title elements of the book elements of the bookstore element that have a price element with a value greater than 35.00
*	Matches any element node
@*	Matches any attribute node
node()	Matches any node of any kind
/bookstore/*	Selects all the child element nodes of the bookstore element
//*	Selects all elements in the document
//title[@*]	Selects all title elements which have at least one attribute of any kind
//book/title | //book/price	Selects all the title AND price elements of all book elements
//title | //price	Selects all the title AND price elements in the document
/bookstore/book/title | //price	Selects all the title elements of the book element of the bookstore element AND all the price elements in the document
ancestor	Selects all ancestors (parent, grandparent, etc.) of the current node
ancestor-or-self	Selects all ancestors (parent, grandparent, etc.) of the current node and the current node itself
attribute	Selects all attributes of the current node
child	Selects all children of the current node

(Continues)

K1. *(Continued)*

Expression	Description
descendant	Selects all descendants (children, grandchildren, etc.) of the current node
descendant-or-self	Selects all descendants (children, grandchildren, etc.) of the current node and the current node itself
following	Selects everything in the document after the closing tag of the current node
following-sibling	Selects all siblings after the current node
namespace	Selects all namespace nodes of the current node
parent	Selects the parent of the current node
preceding	Selects all nodes that appear before the current node in the document, except ancestors, attribute nodes and namespace nodes
preceding-sibling	Selects all siblings before the current node
self	Selects the current node
child::book	Selects all book nodes that are children of the current node
attribute::lang	Selects the lang attribute of the current node
child::*	Selects all element children of the current node
attribute::*	Selects all attributes of the current node
child::text()	Selects all text node children of the current node
child::node()	Selects all children of the current node
descendant::book	Selects all book descendants of the current node
ancestor::book	Selects all book ancestors of the current node
ancestor-or-self::book	Selects all book ancestors of the current node - and the current as well if it is a book node
child::*/child::price	Selects all price grandchildren of the current node
|	Computes two node-sets
+	Addition
-	Subtraction
*	Multiplication
div	Division
=	Equal
!=	Not equal
<	Less than
<=	Less than or equal to
>	Greater than
>=	Greater than or equal to
or	or
and	and
mod	Modulus (division remainder)

Appendix L: Archetypes of Schematron Queries

This appendix contains the main types of Schematron-based queries.

L1. Archetpyes of Schematron Queries

Query Type	Query in Schematron Language
Symptoms in which the presence or lack of certain type of attributes has to be investigated	<pattern name="S.02 Undefined business process goals, business process owners"> <rule context="Object Definition[@Node Type='{*business process task*}’]"> <assert test="Attribute Definition[@AttributeDefinition.Type= '{*process goal* OR *responsible person*}’]"> Alert: S.02. </assert> </rule> </pattern>
	<pattern name="S.32 Lack of data ownership"> <rule context="Object Definition[@Node Type='{*data entity*}']"> <assert test="Attribute Definition[@AttributeDefinition.Type= '{*responsible person*}']"> Alert: S.32 </assert> </rule> </pattern>
Symptoms in which the cardinality of certain connection types has to be analysed ▪ One particular model is analysed in terms of connection cardinality	<pattern name="S.05/A Undefined or multiple hierarchy or lines of reporting"> <rule context="Object Definition[@Node Type='{*business collaboration*}']"> <report test="@ObjectDefinition.ID=following-sibling:: [@Node Type= '{*business collaboration*}']/Connection Definition[@Connection Definition.Type ='{*has superior*}']/@ToObjectDefinition.IdRef or @ObjectDefinition.ID= preceding-sibling::ObjectDefinition[@Type Num='{*business collaboration*}']/ Connection Definition[@Connection Definition.Type='{*has superior*}']/@To ObjectDefinition.IdRef"> Alert: S.05/A </report> </rule> </pattern> <pattern name="S.05/B Undefined or multiple hierarchy or lines of reporting"> <rule context="Object Definition[@Node Type='{*business collaboration*}']"> <report test="Connection Definition[@ToObjectDefinition.IdRef= parent:: Object Definition/following-sibling::Object Definition[@Node Type='{*business collaboration*}']/Connection Definition[@Connection Definition.Type='{*has superior*}']/@ToObjectDefinition.IdRef] or Connection Definition[@ToObject Definition.IdRef= parent::Object Definition/predecing-sibling::Object Definition[@Node Type='{*business collaboration*}']/Connection Definition[@ Connection Definition.Type='{*has superior*} ']/@ToObjectDefinition.IdRef] "> Alert: S.05/B </report> </rule> </pattern>

(Continues)

L1. *(Continued)*

Query Type	Query in Schematron Language
Symptoms in which the cardinality of certain connection types has to be analysed ▪ Sole model variants are analysed in terms of connection cardinality and the query is processed for every available model variant	<pattern name="S.07. Business process task supported by more than one application"> <rule context="Object Definition[@Node Type='{*business process task*}']"> <report test="count(Connection Definition [@ToObjectDefinition.IdRef=parent::Object Definition/following-sibling::Object Definition[@Node Type='{*application function*}'] /@ObjectDefinition.ID or @ToObject Definition.IdRef=parent::Object Definition/preceding-sibling::Object Definition[@Node Type= '{*application function*}']/ @ObjectDefinition.ID])>1"> Alert: S.07. </report> </rule> </pattern>
Symptoms in which more models have to be compared ▪ Model variants have to be compared with another group of model variants according to the project phases	<pattern name="S.52 Not all data entities attributes are read at least by one process"> <rule context="Object Definition[@Node Type='{*data entity*}']"> <assert test="Attribute Definition[@AttributeDefinition.Type= '{*attribute name*}']//PlainText[@TextValue=document ('process flow diagram.xml')// Object Definition[@Node Type='{*data entity*}'] //Attribute Definition[@ AttributeDefinition.Type='{*attribute name*}'] //PlainText//@TextValue]"> Alert: S.52 </assert> </rule> </pattern>
Symptoms in which more models have to be compared ▪ Model variants have to be compared with a static catalogue	<pattern name="S.16. Out of date technological infrastructure "> <rule context="Object Definition[@Node Type='{*application system*}']"> <assert test="Attribute Definition[@AttributeDefinition.Type=' {*attribute version*}']//PlainText[@TextValue=document ('technological element catalogue.xml')//Object Definition[@Node Type='{*application system*}']// Attribute Definition[@Attribute Definition.Type='{*attribute version*}']// PlainText//@TextValue]"> Alert: S.16 </assert> </rule> </pattern>
Symptoms in which more model variants have to be analysed and compared during the progression of the project	<pattern name="S.18. Incompatible platforms or technologies"> <rule context="Object Definition[@Node Type='{*hardware component*}']"> <assert test="Attribute Definition[@AttributeDefinition.Type='{*attribute name*}']//PlainText [@TextValue=document('technological element catalogue.xml')//Object Definition[@Node Type='{*hardware component*}'] //Attribute Definition[@AttributeDefinition.Type= '{*attribute name*}'] //PlainText/@TextValue]"> Alert: S.18 </assert> </rule> </pattern>

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Journal Article

[1]

Dóra Őri [2016]: An Artifact-Based Framework for Business-IT Misalignment Symptom Detection. In Horkoff, J., Jeusfeld, M., Persson, A. (Eds.) *The Practice of Enterprise Modeling.* Lecture Notes in Business Information Processing, Vol. 267, ISBN: 978-3-319-48392-4, Springer Berlin Heidelberg, pp. 148-163., DOI: https://www.doi.org/10.1007/978-3-319-48393-1_11

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Dóra Őri [2015]: Towards Detecting Misalignment Symptoms: An Alignment Perspective-Driven Architecture-Matching Framework. In Barjis, J., Pergl, R., Babkin, E. (Eds.) *Enterprise and Organizational Modeling and Simulation*. Lecture Notes in Business Information Processing, Vol. 231, ISBN: 978-3-319-24625-3, Springer Berlin Heidelberg, pp. 214-232., DOI: https://www.doi.org/10.1007/978-3-319-24626-0_16

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List of Paper Abstracts

POEM 2016 – Springer LNBIP Journal Article

An Artifact-Based Framework for Business-IT Misalignment Symptom Detection

Abstract. Enterprise architecture-based approaches give an in-depth analytic potential for alignment and misalignment assessment. The ability to incorporate these analytic potentials is an ongoing concern in the state-of-the-art strategic alignment literature. This paper proposes a framework for EA artifact-based misalignment symptom detection. The framework aims to perform a systematic, EA-based analysis of mismatches between the business and IT dimensions of the traditional Strategic Alignment Model (SAM). By operating the framework, containing EA-artifacts and suitable EA analysis types are connected to typical misalignment symptoms along the traditional alignment perspectives. The operation of the framework is illustrated with a case study about a fleet management project at a road management authority.

EMISA 2016 – CEUR-WS Proceedings and EMISA Forum Publication

Towards Detecting Misalignment Symptoms: An Alignment Perspective-Driven Architecture-Matching Framework (Extended Abstract)

Abstract. When assessing the harmony between business and information systems, most of traditional studies deal with the presence and the achievement of strategic alignment. On the contrary, exiguous attention is paid to the phenomenon of strategic misalignment, which means the absence or difficulties of business-IT alignment. This paper deals with strategic misalignment between business and information systems. It proposes an enterprise architecture (EA)-based framework to detect the symptoms of misalignment in enterprise architecture models. It collects typical misalignment symptoms along the traditional alignment perspectives and connects them to relevant EA analysis types. The paper discusses the typical signs of strategic misalignment in different EA domain matches. Suitable EA analysis types are recommended to the detected signs of misalignment. The work summarized in this extended abstract has been published in Dóra Őri: Towards Detecting Misalignment Symptoms: An Alignment Perspective-Driven Architecture-Matching Framework. Enterprise and Organizational Modeling and Simulation. Lecture Notes in Business Information Processing, Vol 231. Springer Berlin Heidelberg, 2015.

EOMAS 2015 – SPRINGER LNBIP JOURNAL ARTICLE

Towards Detecting Misalignment Symptoms: An Alignment Perspective-Driven Architecture-Matching Framework

Abstract. When assessing the harmony between business and information systems most of traditional studies deal with the presence and the achievement of strategic alignment On the contrary, exiguous attention is paid to the phenomenon of strategic misalignment, which means the absence or difficulties of business-IT alignment. This paper deals with strategic misalignment between business and information systems. It proposes an enterprise architecture (EA)-based approach to detect the symptoms of misalignment in enterprise architecture models. The proposed framework aims to perform an EA-based systematic analysis of mismatches between the business dimension and the IT dimension. It collects typical misalignment symptoms along the traditional alignment perspectives and connects them to relevant EA analysis types. The paper discusses the typical signs of strategic misalignment between business and information systems detected in different EA domain matches. Suitable EA analysis types are recommended to the detected signs of misalignment.

IJCSIS JOURNAL 9(2) 2014

Misalignment Symptom Analysis based on Enterprise Architecture Model Assessment

Abstract. Business–IT alignment and misalignment are duality-like concepts referring to the harmony or disharmony between business and IT. The state between these two areas can be viewed either through its presence (a.k.a. alignment) or through its absence or difficulties (a.k.a. misalignment). Most of alignment studies deal with alignment achievement, while misalignment issues (detecting, analysing and correcting misalignment) are underemphasized in the literature. This paper relates to misalignment assessment. It connects misalignment analysis to enterprise architecture models with the aim to set up an enterprise architecture-based (mis)alignment assessment method. The paper first introduces the primary building blocks of architecture-based misalignment analysis. Based on the theoretical foundation the paper aims to establish the conceptual body of enterprise architecture-based misalignment symptom analysis. Different misalignment symptoms are located on TOGAF metamodel in order to detect the presence of misalignment. At the end of the paper conclusions are drawn concerning the symptom-location experiment.

MCCSIS 2014 – IADIS CONFERENCE PROCEEDINGS

Misalignment symptom analysis based on enterprise architecture model assessment

Abstract. Business–IT alignment and misalignment are duality-like concepts referring to the harmony or disharmony between business and IT. The state between these two areas can be viewed either through its presence (a.k.a. alignment) or through its absence or difficulties (a.k.a. misalignment). Most of alignment studies deal with alignment achievement, while misalignment issues (detecting, analysing and correcting misalignment) are underemphasized in the literature. This paper relates to misalignment analysis. It connects misalignment analysis to enterprise architecture models with the aim to set up an enterprise architecture-based (mis)alignment assessment method. The paper first introduces the primary building blocks of architecture-based misalignment analysis. Based on the theoretical foundation the paper aims to establish the conceptual body of enterprise architecture-based misalignment symptom analysis. Different misalignment symptoms are located on TOGAF metamodel in order to detect the presence of misalignment. In the end of the paper conclusions are drawn concerning the symptom-location experiment.

SEFBIS JOURNAL 2014/1

Analysing Enterprise Architecture Models to Detect Misalignment Symptoms

Abstract. Business–IT alignment has been one of the top information management concerns since the organizational role of information systems has accentuated. The state of alignment between business and IT can be analysed either through its presence (alignment) or through its absence or deficiencies (misalignment). Most of traditional alignment studies deal with achieving alignment. On the contrary, misalignment issues (detecting, analysing and correcting misalignment) are considerably underemphasized in the literature. This paper relates to misalignment analysis. The state of (mis)alignment can be examined via several methods. Analysing enterprise architecture models to detect misalignment is a possible examination approach. The paper aims to introduce architecture assessment-based misalignment analysis from a theoretical perspective. With regard to the theoretical foundation the paper focuses on presenting an initial research plan, pointing out the conceptual body of the proposed research.

Analysing enterprise architecture models to detect misalignment symptoms

Abstract. Business–IT alignment has been one of the top information management concerns since the organizational role of information systems has accentuated. The state of alignment between business and IT can be analysed either through its presence (alignment) or through its absence or deficiencies (misalignment). Misalignment can be referred to as a state occurring when organisations fail to achieve or sustain alignment.

Most of traditional alignment studies deal with achieving alignment. On the contrary, misalignment issues (detecting, analysing and correcting misalignment) are considerably underemphasized in the literature. Organisations are in the state of misalignment as long as they achieve the state of alignment. This fact indicates that more attention has to be paid to the phenomena of misalignment, as well as to its symptoms and effects.

The state of misalignment can be examined with several methods. It is commonly known that one of the main research methods of analysing alignment is enterprise architecture based assessment. Enterprise architecture models are becoming increasingly popular in these days. A possible improvement of enterprise architecture based alignment assessment is to conduct the evaluation from the opposite perspective: assessing misalignment through enterprise architecture models. In this case the purpose of analysing enterprise architecture models is to assess the state of misalignment and to reveal its emerging symptoms.

The research aims to analyse misalignment via enterprise architecture assessment. The goal of the research is to create a tool (research model) that reveals the state and symptoms of misalignment. The qualitative research builds on case studies; the results of applying the research tool will be presented in case studies. The research contributes to theory and practice as well: Its innovative approach conduces to academic business-IT alignment results. Additionally, its practical application helps organisations to detect and correct misalignment in order to achieve the state of alignment.