

# **Universiteit Leiden**

## **ICT in Business**

Optimizing organizational flexibility with Enterprise Architecture measures

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MASTER'S THESIS

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"Flexibility is a requirement for survival." Roger Von Oech

"A bend in the road is not the end of the road...Unless you fail to make the turn." Helen Keller

## Abstract

These days many organizations have to deal with changes in their internal and external environment. Organizations have to deal with changes like necessary cutbacks and rapid technology changes. Because of these reasons organizations are constantly searching for ways to prepare themselves to respond to these changes more easily. A lot of the organizations see flexibility as the solution and want to introduce flexibility in their organization. They often struggle with flexibility, because they do not exactly know how to make it work for their organization.

The main research question we try to answer with this research is "How can organizations take effective measures in developing their Enterprise Architecture to increase flexibility." The main goal of this research is to develop a model that can help organizations to take effective measures in their Enterprise Architecture to increase flexibility. To be able to answer the main research question and build the model the research question was divided into four sub questions that will be answered by this study. The first sub question is focused on exploring why flexibility is important for organizations. The second question is about how organizations can determine what kind of flexibility is needed. The third question is focused on collecting Enterprise Architecture measures that can provide the desired flexibility. And the last question is about how organizations will be combined to create a model to answer the main research question.

A literature study has been performed to collect relevant data on the research topic and answer the research questions. Additional data was collected by conducting a document review within a governmental organization (Rijkswaterstaat). The data from the literature study and the document review were used to formulated interview questions. A total of 7 people that work within the Enterprise Architecture domain were interviewed to gather the relevant data. Four of them work within the Rijkswaterstaat organization and the other 3 work within other governmental or semi-governmental organizations. The data was analyzed and coded for theory building and to identify interesting concepts. The research results were validated during a validation session with experts.

The research delivered various results, first of a proposal for definition of flexibility in Enterprise architecture. Subsequently, the most important elements of Enterprise Architecture where identified. The main result of this research is a conceptual model with structured steps to help organizations with the implementation of effective measures in their Enterprise Architecture to increase flexibility. The model was developed by incorporating the results from the sub questions and includes the following steps: identification of driving forces of flexibility, determination of the necessary flexibility, selection of flexibility measures, implementation and evaluation. All the steps in the model are linked to the TOGAF ADM Cycle Phases. The proposed model was validated by experts in a validation meeting.

The proposed model was only validated during a validation session, it would be useful to validated the model in future research by applying it to an actual case. Furthermore, this research mainly focused on governmental organizations. Another suggestion for future research is to perform similar research focused on for-profit organizations and compare the results.

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## 1. Introduction

This chapter will give an introduction to the research context. The chapter will start with the problem description. Next, two important definitions, the research, -objective and –questions will be described. The chapter ends by describing the scientific relevance of the research and the thesis outline.

## 1.1 Problem description

These days a lot of organizations face necessary cutbacks, which causes the fact that they have to organize their work differently. At the same time productivity has to remain stable or even increase. Due to this organizations are constantly seeking for ways to organize their processes more efficiently to be able to adapt to changes more easily. The problem is that there are many types of change and that change is a very broad concept. Furthermore, the business processes of organizations are highly supported by Information Technology (IT) and IT is becoming even more integrated. This means that if the business processes of an organization change, the related IT systems should facilitate this change and not frustrate it or introduce high cost to change them. A lot of the present IT systems in use by organizations are legacy systems that were built to execute specific tasks. Legacy systems are often custom built and difficult to change. Also changing these systems is not without risks because they are often tightly coupled. If the parts of a legacy system are tightly coupled to one another it makes them extremely sensitive to changes. These kind of systems lack maintainability, adaptability and reuse. (Lauder et al 2000). The challenge which many organizations have to deal with is that the business environment demands for flexible IT systems and architecture that can adapt to changes more easily. To achieve this there should be a good alignment between the business and IT department. The IT department has to understand what the desired flexibility of the business is and support this by incorporating flexibility in the architecture. In this way IT can be prepared to respond to the different types of change that occur in the business environment. There are changes that are reasonably predictable, but also changes that are difficult to predict. In order to deal with both types of changes, an organization needs to be *flexible* (David Sprott 2005). It seems that by being *flexible* organizations can prepare themselves for the uncertainties that the future brings.

Some questions that arise from this problem description are; What is *flexibility*?, What kind of *flexibility* is desired?

Suarez et al.,(1995) wrote a paper about *flexibility* in manufacturing systems and indicate that *flexibility* can be seen as a multi-dimensional concept and not one of single definition. Based on this, organizations should find and set a proper definition of *flexibility* to make *flexibility* work for their organization. Furthermore, *flexibility* has to serve a particular purpose, just making everything flexible will not work and can be very costly as well.

#### If we summarize our findings so far;

Organizations should determine what they need flexibility for and what they want to achieve with it. Based on this they can find and set a proper definition of *flexibility* for their organization. When the right definition of flexibility is set and the they can determine why they want *flexibility*, organizations can take effective measures in their Enterprise Architecture to increase flexibility.

## 1.2 Definitions

#### 1.2.1 Defining Enterprise Architecture

One of the terms used in this research is Enterprise Architecture. To get a better understanding of what Enterprise Architecture stands for we will split the term in "Enterprise" and "Architecture" and search for definitions in two different online dictionaries.

The search in the Merriam Webster dictionary<sup>1</sup> resulted in 4 possible definitions of the term "Enterprise". The following definition was selected, because it's the most common one: "a unit of economic organization or activity; especially : a business organization."

The online dictionary Webopedia<sup>2</sup> elaborates on the above definition and adds the following to it: "*In the computer industry, the term is often used to describe any large organization that utilizes computers. An intranet, for example, is a good example of an enterprise computing system.*"

Based on the definitions that were found in the online dictionaries Enterprise will be defined as follows: a medium-sized or a large business organization.

The same steps were executed to come up with a definition of "Architecture":

The search in the Merriam Webster dictionary resulted in 5 possible definitions of "Architecture". The following definition was selected, because it suits the domain our research is focused on the best:

*"the manner in which the components of a computer or computer system are organized and integrate"* 

And the online dictionary Webopedia defines "Architecture" as follows: "A design. The term architecture can refer to either hardware or software, or to a combination of hardware and software. The architecture of a system always defines its broad outlines, and may define precise mechanisms as well."

By merging the results of the search for the definitions together the proposed definition of Enterprise Architecture is: A high-level design which describes the organizational structure and (information) systems of a medium-sized or large organization.

The proposed definition above was compared with 10 other definitions that were found on the internet. The full list of definitions can be found in Appendix B, the one that fits the best with the proposed definition is the one of The ArchiMate Foundation:

"A coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organizational structure, business processes, information systems, and infrastructure "

Chapter 2 will give a further introduction and overview of Enterprise Architecture and its basic concepts based on the literature review that was executed.

#### 1.2.2 Defining flexibility

Another term used in this research is *flexibility*. Golden, W., & Powell, P. ,(2000) indicate in their paper that when researching flexibility the same problem that reoccurs is the definition. It seems that the definition of flexibility is a multi-dimensional one and not one of single

<sup>&</sup>lt;sup>1</sup> <u>http://www.merriam-webster.com/dictionary/enterprise</u>

<sup>&</sup>lt;sup>2</sup> http://www.webopedia.com/TERM/E/enterprise.html

definition (Suarez et al.,1995). Also, de Haan et al (2011) agree with this and argue that flexibility is a term that is used in various fields with a wide range of different interpretations and meanings.

Based on these findings it is important that we work towards a definition that matches our research focus: Enterprise Architecture flexibility. We will first start by exploring a general definition of flexibility and gradually work towards a definition we will use in our research.

As mentioned before the term flexibility is multi-dimensional and there are many different definitions of *flexibility* in use in various fields. To get a first general overview of the definition we searched the Merriam-Webster dictionary and the Oxford dictionary on the input terms *flexibility* and *flexible*. The Oxford dictionary gave the following definitions:

Flexible:

Able to be easily modified to respond to altered circumstances:

Flexibility:

The ability to be easily modified: Willingness to change or compromise:

And the Merriam-Webster dictionary gave the following results:

Flexible:

- : capable of bending or being bent
- : easily changed : able to change or to do different things
- : willing to change or to try different things

#### Flexibility

"characterized by a ready capability to adapt to new, different, or changing requirements"

These first findings give a strong indication that flexibility has to do with *change*. Furthermore, it seems that you can prepare for change by incorporating *flexibility*.

Based on the definitions found the following definition of flexibility is proposed and will be used in this research: *"Flexibility is the ready capability of Enterprise Architecture to adapt to changing circumstances"* 

## 1.3 Research objective

The main question that arises from the problem description is:

"How can organizations take effective measures in developing their Enterprise Architecture to increase their flexibility."

Main research objective:

This research will focus on how organizations can determine the desired flexibility and integrate effective measures in their Enterprise Architecture (EA).

## 1.4 Research questions

To be able to answer our main research question we divide it into the following four sub research questions:

1) Why is it important for organizations to have flexibility in their Enterprise Architecture? To be answered by conducting a literature study and interviews with a number of key stakeholders.

2) How can organizations determine the desired flexibility? To be answered by conducting a literature study and interviews.

3) Which Enterprise Architecture measures can be used to reach the desired flexibility? To be answered by conducting a literature review and interviews with key stakeholders. And by reviewing current architecture documentation.

4) How should organizations implement the measures in their Enterprise Architecture? To be answered by combining the results of question 1, question 2 and question 3 to create a model, approach or method and verify it by applying it to an actual case.

## 1.5 Contributions of the research

This research will provide insight in which Enterprise Architecture measures can help organizations to deal with the "flexibility challenge". Most research on the flexibility aspect within Enterprise Architecture is focused on the use of Service Oriented Architecture (SOA). This research aims to generate new knowledge about the measures that organizations could take in their Enterprise Architecture to make the IT more resistant to future changes that occur. The main goal of the research is to develop a flexibility implementation model with an approach that organization could use to implement effective measures in their EA. Based on the findings from the literature and interviews a conceptual model will be proposed.

### 1.6 Thesis outline

Chapter 1 describes a general introduction on the research topic. It consists of the following parts: a short introduction on the topic, the research objective and research questions and the contributions of the research.

Chapter 2 describes the research methods used to execute the research.

Chapter 3 describes the theoretical framework.

Chapter 4 describes the results of the research.

Chapter 5 describes the conclusions and discussion.

## 2. Research methods

This chapter describes the research approach and methods that were used during the execution of this research.

## 2.1 Research design

The research is structured into 10 steps, see figure 1.



#### Figure 1: Thesis research design

Brief description of the steps:

Step 1: Literature study

Literature study is conducted to gain more knowledge about the research topic in general. The results of the literature study will serve as input to set up the interview questions and they will be used as a reference to analyze and identify similarities in the document review phase.

#### Step 2: Document review

A document review of EA documents will be executed to explore if and what organizations do in their EA to achieve more flexibility. The outcomes of the document review will also be used to formulate interview questions and compare them with the results of the literature review.

#### Step 3: Data analysis

After completion of the literature study and document review an analysis will be done for better understanding of the problem, to draw the theoretical framework and to collect relevant facts and concepts.

#### Step 4: Formulate interview questions

The interview questions will be structured and formulated based on the results of the data analysis.

Step 5: Review interview questions

The goal of the interviews is mainly to collect relevant data and the questions have to be concise and clear to the interviewee. To ensure this, the questions will be reviewed by a select group of experts. Based on the outcome of the review some adjustments can be made.

#### Step 6: Execute pilot interview

A pilot interview will be executed to practice the interview, check if the questions and answers deliver the right data and to measure the time that is needed to execute the interview. Based on the outcomes some adjustments can be made.

Step 7: Execute interviews

With the right set of questions the real interviews can be executed.

Step 8: Validation of interview data & Data analysis

The collected interview data will be transcribed. The transcribed interview data will be sent to the relevant interviewees to validate it. This is done to ensure that no mistakes and errors have been made during the transcription. After the validation the data will be collected in a spreadsheet and tagged to identify interesting and important data. Findings and conclusions will be collected.

Step 9: Build theory

After the previous steps and based on the results, theory can be built to answer the main and sub research questions.

Step 10: Validation and conclusions

The research results will be validated by arranging a validation meeting with experts. After the validation meeting final conclusions of the research will be drawn.

The most important elements of the research methods used will be described in more detail in the following paragraphs.

#### 2.1.1 Literature study

To explore the current state of the literature and the research gap on the topic, a literature study was conducted using the following sources:

Google Scholar<sup>3</sup> and the Leiden University catalogue<sup>4</sup> were used to find relevant literature.

The literature study was executed to gain more understanding of Enterprise Architecture in general and the *flexibility* component within Enterprise Architecture. Furthermore, the literature study gave more insight in the actual problem, definitions, concepts and related work. Finally, the literature study created a grounded base for the research done. The results of the literature study are compared with the results of the document review and used as a basis for formulating the interview questions.

The following keywords where used:

Architectural flexibility, Enterprise Architecture, Flexible, Flexibility, Information systems, Uncertainty, Change.

The articles are selected by using the following criteria:

- Relevance based on the titles
- The information found in the abstracts

#### 2.1.2 Document review

Next to the literature study a document review will be executed to gather more practical information about the research topic. The document review will be conducted within the Rijkswaterstaat organization<sup>5</sup>. Related architecture documents of the Centrale Informatievoorziening department will be reviewed. The architecture documents include the following type of documents:

- Architecture vision document
- Architecture principles
- Architecture blueprints

The documents are screened on the terms *flexible (in Dutch flexibel), flexibility (in Dutch flexibiliteit).* 

The total list of documents that were reviewed and analyzed can be found in Appendix A.

<sup>&</sup>lt;sup>3</sup> http://scholar.google.nl/

<sup>&</sup>lt;sup>4</sup> http://catalogue.leidenuniv.nl/primo\_library/libweb/action/search.do?vid=UBL\_V1

<sup>&</sup>lt;sup>5</sup> https://www.rijkswaterstaat.nl/

#### 2.1.3 Semi-structured Interviews

Based on the findings from the literature and the document review, interview questions are formulated for the semi-structured interviews. The interviews are divided into the following 4 parts:

• General

The questions in the general part of the interview are formulated to collect general information about the participant, the organization and background information.

#### • Enterprise Architecture

The questions in the Enterprise Architecture part are focused on how Enterprise Architecture is organized within the organization and the most important elements of it.

• Flexibility

The questions in the flexibility part mainly are focused on why the organization needs flexibility and how it deals with flexibility.

<u>Statements</u>

The last part of the interview consists of 8 statements that are formulated based on the findings from the literature study.

The list of interview questions can be found in Appendix C

#### Selection of participants

A selection of different architects within the organization are selected to participate in the interviews. To gather relevant information on different levels the interviewees included enterprise architects, domain architects and solution architects. To get more relevant and representative information the group of interviewees exist out of internal and external architects that work at different organizations. In total 4 different architects within the Rijkswaterstaat organization will be interviewed and 3 architects from other organizations. The selected organizations consist of both governmental and semi-governmental organizations. The e-mail (in Dutch) that is used to contact the interviewees to participate in the interview can be found in appendix D.

#### 2.1.4 Data analysis

#### Coding of literature

Based on the sub research questions the collected articles are grouped into four groups (themes): why flexibility, determine flexibility, flexibility measures and Implementation of flexibility.

Open coding is used to analyze the literature. The literature will be labeled based on the findings indicated by the literature. (Pandit 1996). The labeling results in concepts as a basis for grounded theory construction. The gathered data will be compared and categorized into sub-codes.

The tool MAXQDA is used to support the coding process.

#### Transcription and coding of the interview data

During the interviews the collected interview data will be directly transcribed into text to be able to analyze the data later on. Before we code the data to analyze it, the transcripts will be sent to the interviewees to validate and complement the collected data.

After the interview transcriptions are received back from the interviewees coding will be applied to analyze the collected data. The themes and sub-codes that are used in the coding of the literature will be used as a starting point. During the coding process of the interviews sub-codes will be added if relevant.

#### 2.1.5 Validation by expert meeting

Validation of the research results will be done by arranging a validation meeting with experts.

The expert meeting will serve as a basis to test the usefulness of the research results. Based on the feedback received from the experts some improvements to the end results can be made as well.

The group of experts will consist of the following persons: One enterprise-, domain- and solution architect from the Rijkswaterstaat Centrale Informatievoorziening department. The people selected all work on different levels within the architecture domain to gather input from architecture views. During the validation meeting the research design and end results will be presented to the group of experts. During the presentation survey questions will be asked to validate the results of the conducted research.

See Appendix G for the presentation and survey questions that were used in the expert meeting

## 3. Theoretical framework

In this chapter an overview of related theory on the research topic will be described. This theory is relevant for the research, it will create a main understanding of Enterprise Architecture and flexibility and their related concepts. The theory will serve as input for the flexibility implementation model.

## 3.1 Enterprise Architecture

In chapter 1 a definition was set for Enterprise Architecture that gave a basic understanding of what Enterprise Architecture is. In the following paragraphs the basic elements of Enterprise Architecture will be described to understand how Enterprise Architecture is organized.

#### 3.1.1 Enterprise Architecture frameworks

The research is focused on flexibility and Enterprise Architecture. In this paragraph an short introduction to Enterprise Architecture frameworks will be given and the framework that is in use by the case organization will be described.

Enterprise Architecture was founded as an idea of John A. Zachman in 1980. He was also one of the first that came up with an Enterprise Architecture framework in 1987. The Zachman Architecture framework, see figure 1, was created as a reference to help organizations cope with increasing complexity and evolving new business trends and IT. (H. Shah., 2007). In the past years many different types of Architecture frameworks have been developed according to Cameron et al., (2013) the five major used frameworks are: The Zachman framework, the TOGAF® Standard, FEAF (Federal Enterprise Architecture Framework), DoDAF (Department of Defense Architecture Framework), and Gartner.

ZIFA mega	WHAT	ноw	WHERE	wно	WHEN	WHY
	DATA	FUNCTION	NETWORK	PEOPLE	TIME	MOTIVATION
SCOPE {contextual} Planner Designer	Things important to the business	List of processes the business performs	List of locations where the business operates	List of organizational units	List of Events significant to the business	List of business goals/strategies
ENTERPRISE MODEL {conceptual} Owner Designer	Semantic Model	Business process model	Business Logistics Systems	Organization chart, role, skill sets, security issues	Master Schedule	Business Plan
SYSTEM MODEL {logical} Designer	Logical Data Model	Application Architecture	Distributed system architecture	Human interface architecture	Processing Structure	Business rule model
TECHNOLOGY MODEL {physical} Designer	Physical Data Model	System design	Technology System Architecture	Presentation Architecture	Control structure	Rule design
DETAILED REPRESENTATIONS Designer Programmer	Data Definition	Program	Network Architecture	Security Architecture	Timing definitions	Rule specification

Figure 2: The Zachman Architecture framework

In the context of the research the following interview question was formulated to gather additional information from the interviewees on which framework they use:

• Do you use an Enterprise Architecture framework? (Which one? Why that one?)

The majority of the interviewees indicated that they use the TOGAF architecture framework, see figure 2. They mentioned various reasons why they chose for TOGAF. Below an overview of the most common reasons:

"We choose for TOGAF because it is an open standard that is widely used and popular."

"Actually, all frameworks are similar on general aspects, but TOGAF is more elaborated based on new insights and knowledge."

"The advantage of TOGAF is that it describes the architecture processes"

"We use Archimate as architecture language. Both Archimate and TOGAF are developed by the Open Group."

Because the research is done for an organization that uses TOGAF and also a majority of the interviewees indicated that they use TOGAF as an architecture framework, TOGAF is used as a reference framework in this research. In the following paragraphs some general elements of Enterprise Architecture will be described.

TOGAF<sup>6</sup> gives the following definition of an architecture framework:

"An architecture framework is a tool which can be used for developing a broad range of different architectures. It should describe a method for designing an information system in terms of a set of building blocks, and for showing how the building blocks fit together. It should contain a set of tools and provide a common vocabulary. It should also include a list of recommended standards and compliant products that can be used to implement the building blocks."

Enterprise Architecture frameworks are based on best practices and can help organizations to organize their business.



Figure 3: Detailed representation of the TOGAF content metamodel

<sup>&</sup>lt;sup>6</sup> http://pubs.opengroup.org/architecture/togaf8-doc/arch/

<sup>&</sup>lt;sup>7</sup> <u>http://pubs.opengroup.org/architecture/togaf9-doc/arch/chap34.html</u>

### 3.1.2 TOGAF ADM Cycle

This section describes the Architecture Development Method Cycle (ADM Cycle) of TOGAF. The TOGAF ADM Cycle will be used as a reference for building up the flexibility implementation model.

The ADM Cycle is used to develop and manage the life cycle of an Enterprise Architecture. The ADM Cycle can be seen as the core of TOGAF. The method integrates several TOGAF elements to meet the Business and IT needs of an organizations. The TOGAF ADM Cycle is shown in figure 4.



The ADM	Cvcle	consists	of	different	phases.

Phase	Short description
A- Architecture Vision	The Architecture Vision describes a high level architecture
B- Business Architecture	See paragraph 3.1.3 for a description of this phase
C- Information Systems Architecture	See paragraph 3.1.3 for a description of this phase
D- Technology Architecture	See paragraph 3.1.3 for a description of this phase
E- Opportunities and Solutions	The Opportunities and Solutions phase focusses on how the architecture should be delivered. Based on the complete set of gaps between the Target and Baseline Architectures for all architecture domains, logical group changes and work packages within the enterprise's portfolios are used as input. The main goal is to build a best-fit roadmap for the architecture.

F- Migration Planning	In this phase the Roadmap and the Implementation and Migration Plan are integrated with the enterprise's other change activity.
G- Implementation Governance	Implementation Governance is used to ensure the enterprise's compliance with the defined architectures. This phase focusses both on implementation projects and other ongoing projects within the enterprise.
H- Architecture Change Management	Architecture Change Management is needed to ensure that the architecture reaches its intended target business value. It ensures that changes to the architecture are done in a cohesive and architected way.

The different phases of ADM cycle are divided into more detailed steps. The Phases A, B and C are further divided into the following steps:

- Select reference models, viewpoints, and tools
- Develop Baseline Architecture Description
- Develop Target Architecture Description
- Perform gap analysis
- Define candidate roadmap components
- Resolve impacts across the Architecture Landscape
- Conduct formal stakeholder review
- Finalize the Architecture
- Create Architecture Definition Document

#### 3.1.3 Enterprise Architecture layers

In this paragraph an overview of the Enterprise Architecture layers according to TOGAF will be given.

TOGAF basically defines 3 architecture layers Business Architecture, Information Systems Architecture and Technology Architecture. The Information Systems Architecture is further divided into a Data and Application architecture.

We will briefly describe each layer according to TOGAF<sup>8</sup>:

Explanation of definitions used:

#### Architecture Vision:

A succinct description of the Target Architecture that describes its business value and the changes to the enterprise that will result from its successful deployment. It serves as an aspirational vision and a boundary for detailed architecture development.

#### Baseline:

A specification that has been formally reviewed and agreed upon, that thereafter serves as the basis for further development or change and can only be changed through formal change, control procedures or a type of procedure such as configuration management.

#### Target Architecture:

The description of a future state of the architecture being developed for an organization. There may be several future states developed as a roadmap to show the evolution of the architecture to a target state.

<sup>&</sup>lt;sup>8</sup> http://pubs.opengroup.org/architecture/togaf9-doc/arch/

#### **Business Architecture:**

The Business Architecture basically describes business strategy including the following aspects of the business environment: Governance, the organization, and the primary business processes and services.

Goals of Business Architecture:

- Development of a Target Business Architecture that describes how the organization must be organized to achieve its business goals and how it responds to strategic drive set in the Architecture Vision.
- Identification of potential Architecture Roadmap components based on a gap analysis between the Baseline and Target Business Architectures.

#### Information Systems Architecture:

The information Systems Architecture describes a combination of Data and Application Architecture.

Goals of Information Systems Architecture:

- Development of a Target Information Systems (Data and Application) Architecture, that describes how the organizations' Information Systems Architecture will empower the Business Architecture and the Architecture Vision.
- Identification of potential Architecture Roadmap components based on a gap analysis between the Baseline and Target Information Systems (Data and Application) Architectures.
  - Data Architecture

The Data Architecture describes the structure of logical and physical data assets and data management resources of an organization.

Goals of Data Architecture:

- Development of a Target Data Architecture that empowers both the Business Architecture and the Architecture Vision.
- Identification of potential Architecture Roadmap components based on a gap analysis between the Baseline and Target Data Architectures
- Application Architecture

The Application Architecture describes a blueprint for applications to be deployed and it describes the interactions and relationships of the applications to the core business processes of an organization.

Goals of Application Architecture:

- Development of a Target Application Architecture that empowers both the Business Architecture and the Architecture Vision.
- Identification of potential Architecture Roadmap components based on a gap analysis between the Baseline and Target Application Architectures.

#### Technology Architecture:

The Technology Architecture describes the needed software and hardware systems that are required to support the Business, Data and Application services.

Goals of Technology Architecture:

- Development of a Target Technology Architecture that empowers the logical and physical application and data components and the Architecture Vision.
- Identification of potential Architecture Roadmap components based on a gap analysis between the Baseline and Target Technology Architectures.

Based on the description of the Architecture layers above we can see that there is a hierarchy between the layers and that the layers impact each other. From a top-down approach the Architecture Vision and the Architecture layers give directions to underlying layers. From a bottom-up approach the underlying layers must conform to the layer(s) on top. According to

Mesarovic et al. (1970) a hierarchical approach reduces the degrees of freedom of the subsequent layers.



Figure 5: TOGAF Architecture layers

#### 3.1.4 Enterprise Architecture principles

In this section another important element of Enterprise Architecture will be described.

From the definition that was determined in the introduction it becomes clear that Enterprise Architecture has to do with principles. According to TOGAF<sup>9</sup> Architecture principles are general rules and guidelines that support and inform about the way an organization is about to fulfill its mission. The Enterprise Architecture approach of Op't Land et al., (2008) and several others indicate that principles are an important element of Enterprise Architecture.

According to Greefhorst et al (2011) there are different kind of drivers for the formulation of architecture principles:

• Goals and objectives:

Targets that internal and external stakeholders want to achieve.

Values:

Quality attributes such as: reliability, sustainability and *flexibility* (they also refer to the ISO 9126 and IEEE 1061 for further explanation of the quality attributes).

• <u>Issues:</u>

Anything that frustrates an enterprise (on strategic, tactical and operational level) in reaching its goals.

- <u>Risks</u>
- Potential problems/issues that may occur.
- Potential rewards
- Business opportunities.
- <u>Constraints</u> Factors defined by others and that cannot be changed. (i.e. laws)

There are different kind of principles that can be defined within Enterprise Architecture. TOGAF distinguish the following types:

- <u>Enterprise principles</u> These principles provide a basis for enterprise-wide decision-making.
- Information technology principles These type of principles give direction on the use and deployment of all IT resources and assets across the enterprise. They are set in order to make the information environment as productive and cost-effective as possible.

<sup>&</sup>lt;sup>9</sup> <u>http://pubs.opengroup.org/architecture/togaf8-doc/arch/chap29.html</u>

#### • Architecture principles

These principles are a subset of Information technology principles that relate to architecture work. They reflect a level of consensus across the enterprise, and embody the spirit and thinking of the Enterprise Architecture.

To illustrate how principles are formulated see the following random example given by TOGAF:

Principle 20:
Interoperability
Statement:
Software and hardware should conform to defined standards that promote interoperability for data, applications, and technology.
Rationale:
Standards help ensure consistency, thus improving the ability to manage systems and improve user satisfaction, and protect existing IT investments, thus maximizing return on investment and reducing costs. Standards for interoperability additionally help ensure support from multiple vendors for their products, and facilitate supply chain integration.
Implications:
<ul> <li>Interoperability standards and industry standards will be followed unless there is a compelling business reason to implement a non-standard solution.</li> </ul>
<ul> <li>A process for setting standards, reviewing and revising them periodically, and granting exceptions must be established.</li> </ul>
The evicting IT platforms must be identified and desumanted

The existing IT platforms must be identified and documented.

3.1.5 Baseline and Target Architectures (As-Is and To-Be)

In this paragraph the Baseline and Target Architecture will be described.

Baseline and Target Architectures are other important elements of Enterprise Architecture. These are also known as As-Is and To-Be architectures. As-Is architectures are commonly created to get insight in the dependencies within an enterprise and to provide the big picture. Whereas To-Be architectures are generally developed to understand and explore the "*impact of change*" or to serve as a blueprint for a change (Bailey, I. 2006).

Wagter et al, (2005) describe the chronological aspect of architecture by the use of As-Is and To-Be architectures: As-Is architectures are used to describe and understand the current situation. Whereas To-Be architectures are created to serve as a blueprint for a future situation.



Figuur 6: Baseline and Target architecture

Based on an As-Is and a To-Be architecture a GAP analysis can be performed to determine the effort it takes to migrate to the desired future state To-Be architecture. Furthermore, a set of set of guidelines (Principles) can be defined to support the transition from the current situation (As-Is) to the desired future situation (To-Be). Additionally, an architecture roadmap and migration plan should be created to support the development process. See figure 6.

The Gartner Group attached a time element to architecture to improve the communication. They describe three type of architectures: Today Architecture (As-Is), Tomorrow Architecture (To-Be) and the Next-minute Architecture (Guidelines). The three types of architectures are visualized in figure 7. According to The Gartner Group (Philip Allega, 2010) a common mistake that organizations make when they start with EA is that they first focus on describing the current state instead of analyzing their business strategy and describing the future state architecture. They argue that focusing on the current state first limits the ability to see future possibilities.



Today architecture Figure 7: Three types of architecture The Gartner Group.

#### 3.1.6 Enterprise Architecture governance

In paragraph 3.1.2 the phases of the TOGAF ADM Cycle were described. One of the phases for developing an architecture is to implement a Governance. To make Enterprise Architecture work it has to be governed. TOGAF defines Architecture Governance as follows:

"The practice and orientation by which enterprise architectures and other architectures are managed and controlled at an enterprise-wide level. It is concerned with change processes (design governance) and operation of product systems (operational governance)."

TOGAF<sup>10</sup> describes that the following aspects are included in a Architecture Governance:

- Implementation of a system that controls the creation and monitoring of all architectural components and activities, to realize a effective introduction, implementation, and evolution of architectures within the organization
- Implementation of a system that ensure compliance with internal and external standards and regulatory obligations.
- Establishing of processes that support effective management of the above processes within agreed parameters.
- Development of practices that ensure accountability to a clearly identified stakeholder community, both inside and outside the organization.

<sup>&</sup>lt;sup>10</sup> http://pubs.opengroup.org/architecture/togaf8-doc/arch/chap26.html

## 3.2 Flexibility

The review of the literature resulted in various concepts and models that relate to flexibility. In this section the collected concept and models will be described.

#### 3.2.1 Architecture Maturity Model and flexibility

In this paragraph the Architecture Maturity model and the relation with flexibility will be described.

The architecture maturity model of Ross et al (2006) describes 4 architecture stages.

In the first stage *Business silos* organizations have local applications for dedicated tasks. In this stage organizations may have various applications and systems in place with overlapping functionality.

In the second stage *Standardized technology* organizations move from the use of local applications to more share resources and shared infrastructure services. In this stage organizations generate cost savings by technology standardization and consolidation.

In the third stage *Optimized Core* organizations move to data sharing and standardization of business processes. Development of shared data services create opportunities to enhance the costumer services.

In the last stage *Business Modularity* organizations invest in a more modular operating model. The organizations are more focused on smaller reusable application and process components that can be used in organization wide business units. If parts business process change only the related modules have to be changed or replaced by others.



Furthermore the model of Ross et al (2006) describes flexibility during the maturity stages. Their model shows that when the Enterprise Architecture of organization matures flexibility is changing, see figure 9. In the higher maturity stages more global flexibility will be achieved for example by the use of shared services and standardization. In the lower maturity stages organizations have more local flexibility, because the business silo decides on themselves which applications and systems to purchase.



#### 3.2.2 Flexibility framework

In this section an existing flexibility framework to introduce flexibility in organizations will be described. The framework contains important factors that should be taken into consideration when working with flexibility.

Pasmore (1994) describes a flexibility framework based on a functional approach. The framework describes six areas where organizations need flexibility.

- People;
- Technology;
- Work;
- Thinking;
- Managers;
- Organisational design.

#### People

The first factor that should be taken into account is the people factor. This factor intends to create flexible people within the organization that take responsibility for change(s). people are more flexible and prepared to participate in their business if both technical and social skills are well developed.

#### Technology

The technology factor is used to focus and introduce more flexible technology. The introduction of flexible technology will make it easier for organizations to respond to certain changes. Technical flexibility is not only about technology. People often ignore or fail to incorporate flexibility in the systems, because of different reasons. One of the reasons can be the available knowledge of people.

#### Work

Another factor is the work factor. This factor is used to introduce work flexibility by forming teams and increasing collaboration. This factor focusses on the organizational design and work allocation. The goal is to create flexible job descriptions and cross-functional collaboration via teams.

#### <u>Thinking</u>

The thinking factor is about the creation of flexibility in thinking to stimulate innovation, experimentation and research and development within organizations. Flexible thinking can be achieved by sharing of knowledge, freedom of movement, involvement of people in goalsetting and an organizational structure which encourages, supports and rewards learning.

#### **Managers**

The managers factor entails to create flexible managers and flexible management within the organization. This often requires changes to the leadership and decision-making processes of organizations. The environment of the organizations should dictate who is best qualified to make decisions and take the lead.

#### Organizational design

The last factor describes the need for a flexible organizational structure. Also known as the fractal organization. The intended target of a fractal structural organizational design is to develop a structure that can constantly adapt to the environment. This structure creates maximum flexibility in what people do and learn with a minimum framework of commonality that is required to guide their actions towards common goals.

#### 3.2.3 Flexibility implementation process model

In this section a flexibility implementation model will be described that may contain relevant information for building the flexibility implementation model .

Koornhof, C. (2003) describes a flexibility implementation process model to implement flexibility in organizations.

The process model starts by creating *awareness* about flexibility and its (long term) objectives for the organization. The *awareness* should be created within and outside the organization.

When *awareness* is created the management of the organization can experiment with the effect of flexibility on their organization. Organizations also have to take the desired flexibility into account, because of competitiveness of markets and competition. This step may result in the identification of certain flexibility with which the organization can gain competitive advantage.

When the experimentation is done the next step is to create *acceptance* for the introduction of flexibility. To create acceptance different aspects have to be taken into consideration like corporate culture, training programs and responsiveness to change. Often certain flexibility already exists in organizations but is not visible because it is not recognized and described as such.

By the *introduction of* a more structured and formal approach on flexibility the existing flexibility will be identified as well as the areas were flexibility is desired. In the *introduction* step the Pasmore framework in the previous paragraph may be used as a starting point.

Once the flexibility objectives are identified by the management, the levels of flexibility should be *measured* by defining effective measures and indicators. The indicators may be used to quantify the targets and measure the progress of the achievement of the flexibility targets.

The indicators for flexibility should be *communicated* within the organization and to the different stakeholders outside the organization to enable them to assess their performance. When organizations have indicators in place they can compare information on flexibility among the organization. In this way *benchmark* industry indicator can be developed.

During the whole implementation process continuous *feedback* and repositioning of the organization is needed.



Figure 10: Flexibility implementation process model

#### 3.2.4 IT Flexibility Framework

In this section another flexibility framework specific for IT will be described.

Regarding de Haan et al (2011), IT infrastructures were typically in place for decades or more, while the customer demands and circumstances change on much shorter timescale. So it is attractive for an organization to have a flexible infrastructure that can adapt to these changes.

According to Patten et al (2005), flexibility should be systematically analysed and introduced within the IT organization. They mention three important aspects in their paper that organizations must use to become more flexible these are: anticipation, agility and adaptability. They linked the three aspects to each other in a continuous model: *The IT Flexibility Framework*, see figure 10 The model begins with "1. Anticipation" to balance the predictable changes and prepare for the unpredictable changes. Next situations and the environment change over time requiring "2. Agility" to respond quickly to these changes. After responding to the changes the organization needs "3. Adaptability" to learn from previous experience. After that the model start over again.



Figure 11: IT Flexibility model

3.2.5 Software Quality characteristics related to flexibility

In this paragraph flexibility in the context of software quality characteristics will be described.

Greefhorst et al (2011) make a reference to the ISO 9126 and IEEE 1061 quality standards to find more about the different quality characteristics such as *flexibility*. The ISO 9126 and ISO/IEC 25010:2011 standard describes a software quality in use model. One of the software quality characteristics is *flexibility*. The ISO/IEC 25010:2011 gives the following definition of flexibility:

The degree to which a product or system can be used with effectiveness, efficiency, freedom from risk and satisfaction in contexts beyond those initially specified in the requirements (ISO/IEC 25010:2011)

The following sub characteristics of flexibility are described in the standard:

• Flexibility to use a product for additional user groups, tasks and cultures.

• Flexibility as an enabler to adapt a product to changing circumstances, opportunities and individual preferences that are not foreseen.

• If a product has no flexibility, the product may not be used in unintended contexts.

• Flexibility can be measured by the extent to which a product can be used other users to achieve certain goals with effectiveness, efficiency, freedom from risk and satisfaction in additional types of contexts of use, or by a capability to be modified to support adaptation for new types of users, tasks and environments, and suitability for individualization as defined in ISO 9241-110.

### 3.3 PESTEL analysis

This paragraph describes the PESTEL analysis that can be used by organizations to scan their environment on different factors.

According to Yüksel, I. (2012) a PESTEL analysis has two functions for organizations. The first function is that it allows organizations to identify their operating environment. The second function of a PESTEL analysis is that it generates information that helps organizations to predict situations and circumstances that might occur in the future. Johnson et al., (2008) describe the PESTEL framework as an analytical tool that is used to identify the key drivers of change that occur in the strategic environment of organizations.

The PESTEL analysis consist of 6 factors to scan the environment. These are: Political, Economic, Social, Technological, Environmental and Legal.

#### Political

The political factor is about governmental decisions and how they affect the (economical) context of an organization. For example by the change of the governmental policy, tax policy and by introducing trade restrictions. Change in political factors often have impact on organizations and how they do business. This factor is used to explore the future developments of the political context.

#### **Economic**

Economic factors focus on the way people spend their incomes. This factor has more impact on business to consumer organizations. The economic factors influence how profitable organizations are and how they do their business. Examples are economic growth and cost savings.

#### <u>Social</u>

The social factors are about the shared belief and attitudes of the population. This factor include the growth of the population, age distribution career attitudes and so on.

#### **Technological**

The technological factor are about the use of technology and the introduction of new technology. Technological landscapes change fast and often have impact on the market and

the products and services of organizations. Technological factors include new ways of creating products and making services available.

#### **Environmental**

The environmental factors are about the geographic location, weather and doing business in a sustainable company. Examples are carbon footprints targets.

Legal

Legal factors have to do with that organizations know which factors are legal and which are not. Examples are health, product safety and labelling. Organizations that operate on a global scale often have to deal with rules and regulation of different countries.



Figure 12: PESTEL analysis

## 3.4 CIMO Logic

To get a better understanding of what organization want to achieve with flexibility CIMO logic can be useful to explore the context, possible interventions, measures and outcomes.

CIMO Logic describes design propositions and contains information about what to do in which situations with what effect and why something happens. (Denyer, 2008). The CIMO logic consist of the following four components: Context, Interventions, Mechanisms and Outcome.

The components are described briefly below:

#### Context

The context component describes internal and external factors and the background that influence organizational change. For example: change in organizational design, technology and politics.

#### Intervention

Interventions are the measures which are undertaken to deliver expected results. The outcome of intervention strongly rely on the implementation and the mechanisms that are triggered.

#### Mechanisms

Mechanisms describe the relation between the interventions and the outcomes. Mechanisms are triggered by Interventions in a certain context.

Outcome An outcome is the result of an intervention. For example: Cost reduction and faster delivery times.

Figure 13 shows an empty CIMO framework.

	Context	
	Intervention (s)	
	Mechanism(s)	
	Outcome (s)	
Fig	ure 13: CIMO framework	

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## 4. Results

In this section the results of the research will be presented. The results will be integrated in a model at the end of this chapter.

## 4.1 Definition flexibility

There are many different factors (Internal or external) that influence the environment of organizations. In this research they are identified as *driving forces of flexibility*. The driving forces trigger the need for flexibility. The driving forces that were collected during the research will be described in paragraph 4.3. First the general definition that was set before in the introduction section (see 1.1.2) will be compared to the definitions that were found in the literature study and collected during the interviews. At the end a final conclusion will be drawn.

#### **Results from literature**

As mentioned before, the term flexibility is one of multiple dimensions and definitions (see 1.1.2.). Existing literature was searched to explore these different dimensions and definitions.

From a business process view Schonenberg et al (2008) define *process flexibility* as the ability of business processes to cope with both foreseen and unforeseen changes. By adjusting only the parts of the business processes that are affected by the changes, the format of the affected parts will not be impacted by the adjustments. In this context *flexibility* is explained as which parts of the business process must stay the same and which parts are allowed to change. In the context of e-business Shi & Daniels (2003) describe *e-business flexibility* as an effective means by which an e-business can hedge against uncertainty in a swiftly changing environment. Furthermore, they argue that flexibility is one of the most important success factors that contributes to e-business success since increasing complexities are constantly generated by technological advancements. Allen & Torrens (2005) confirm that *flexibility* can contribute to success, they argue that *adaptability* and a *flexible* response can be considered as success factors in strategies.

Bernardes et al (2009) collected several definitions of flexibility, these definitions are shown in figure 13 below.

Definition	Reference
Ability to respond effectively to changing circumstances The quickness and ease with which plants can respond to changes in market conditions	Gerwin (1987) Cox (1989)
The adaptability of a system to a wide range of possible environments that it may encounter	Sethi and Sethi (1990)
The ability of a manufacturing system to generate high net revenues consistently across all conceivable states of the nature in which it may be called to function	Ramesesh and Maliyakal (1991)
The ability to cope with changing circumstances or instability caused by the environment	Gupta and Somers (1992)
The ability of the system to quickly adjust to any change in relevant factors like product, process, loads, and machine failure	Nagarur (1992)
A response to external uncertainty A generic ability to adapt to internal and/or external influences The ability of a manufacturing system to change states across an increasing range of volume and/or variety, while adhering to stringent time and cost metrics	Newman <i>et al.</i> (1993) Holweg (2005) Upton (1994, 1995b)
The ability to respond quickly to changing customer needs at reasonable price	Small and Chen (1997)
The capability of an organization to move from one task to another quickly and as a routine procedure Ability of a manufacturing system to change states across an increasing range of volume and/or variety, while adhering to stringent time and cost metrics	Vokurka and Fliedner (1998) Das (2001)
The organization's ability to meet an increasing variety of customer expectations without excessive costs, time, organizational disruptions, or performance losses	Zhang et al. (2003)

Figure 14: List of flexibility definitions

The similarities between the definitions found so far is that they describe *flexibility* as the ability to deal or respond to foreseen and unforeseen (or uncertain) changes. This aligns with what de Haan et al (2011) state in their paper, according to them *flexibility* and its related concepts have been proposed as ways to cope with the uncertainties that the future brings.

The results of the literature study show us that there are a lot of other words that have a close relation with *flexibility*. All these words are often used in the context of change and are seen as a solution to deal with changing circumstances. These words can be seen as flexibility objectives or characteristics of flexibility.

The literature study resulted in the following list of related words:

#### a. Scalability (Ross et al. 2008)

Scalability is the ability to change the level of a parameter.

#### b. Reusability (Boehm 1981)

Reusability is the degree to which a software system or components facilitate the selective reuse of components.

#### c. Maintainability (Mari et al. 2003)

Maintainability is the capability of software systems or components to be modified it is a prerequisite for reusable software.

#### d. Modularity (Sanchez and Mahoney 1996)

Modularity is a special form of design which intentionally creates a high degree of independence or "loose coupling" between component designs by standardizing component interface specifications. Modularity also enables reuse.

#### e. Adaptability (Swafford, Ghosh, & Murthy, 2006). Adaptability is the ability to change within a given state.

#### f. Agility (Sharifi and Zhang, 1999).

Agility is the ability to cope with unforeseen changes by taking advantage of them and seen them as opportunities.

Please note that there may be several other related words around. This list is the result of analysis of the literature that was selected and used for this research.

#### **Results from interviews**

Based on the *flexibility definitions* collected from the literature the following interview questions was formulated to collect additional information from the interviewees:

#### INTERVIEW QUESTION:

Can you define "flexibility" in Enterprise Architecture? (Will be verified with definition extracted from the literature review)

The following definitions of flexibility were given by the interviewees. Some definitions that were given by the interviewees were similar. The interviews resulted in a total of 4 definitions:

#### Definition 1:

Develop architecture that is resistant to all the factors mentioned in the previous questions. These factors are: Political uncertainty (every 4 years there is another government landscape), Organizational uncertainty (It is unclear who decides and when the management changes which direction will be ), Market uncertainty and Technological changes.

#### Definition 2:

Flexibility is the degree to which the IT, opposes to the changing information requests (of the business). Actually, the ease in which IT can move with the changing information requests (of the business).

Definition 3:

Flexibility is the degree to which you can facilitate innovation (from technology and business questions).

Definition 4:

Flexibility is the ability to quickly adjust changes in digital IT. Actually, flexibility is designed maneuverability (this is your primary goal) with stable anchor points.

The similarities between the definitions given by the interviewees is that flexibility seems to be needed to respond to changes that occur in the environmental context of organizations. Different factors of change are mentioned in the definitions like: Innovation, technological changes, political uncertainty, market uncertainty and changing information requests of the business.

The following interview question was asked during the interviews to find out if the organizations where the interviewees work use a clear definition of flexibility within the organization.

INTERVIEW QUESTION:

Is there a clear and unambiguous definition of "flexibility" in Enterprise Architecture used within you organization?

The results on this question in figure 14 show that the majority of the interviewees indicated that there was no definition of flexibility set or known within their organization.



Figure 15: Result flexibility definition

The related words and concepts of flexibility that were found during the literature study were presented during the interviews to determine if the interviewees agreed on them. The interviewees were also asked to add more related words if possible and to rank them in order of importance. The following interview question included in the interviews:

#### INTERVIEW QUESTION:

Flexibility has to do with: (Add more if possible)

- a. Scalability
- b. Reusability
- c. Maintainability
- d. Modularity
- e. Adaptability
- f. Agility

Most of the interviewees agreed on the list of related words. The words and related concepts that were added by the interviewees are presented in table 1 below they are categorized by type.

Word/ related concept	Туре
Scalability	Characteristic/ Objective
Reusability	Characteristic/ Objective
Maintainability	Characteristic/ Objective
Modularity	Characteristic/ Objective
Adaptability	Characteristic/ Objective
Agility	Characteristic/ Objective
Loose coupling	Measure
Interoperability	Characteristic/ Objective
Discoverability	Characteristic/ Objective
Governance	Measure
Open interfaces	Measure
Resiliency	Characteristic/ Objective

Table 1: Related words derived from interviews

Most of the words that were added by the interviewees are characteristics of flexibility and measures to achieve flexibility. Loose coupling, governance and open interfaces are measures to create flexibility. Interoperability, discoverability and resiliency are more like objectives that can be achieved by flexibility. For example if you introduce open interfaces as a measure this may result in more interoperability between systems.

The interviewees prioritized the related words that were found in the literature in the following order:

- 1) Adaptability and Agility
- 2) Reusability
- 3) Maintainability
- 4) Scalability
- 5) Modularity

According to the interviewees adaptability and agility are the most important words that have a relationship with flexibility. They indicated that adaptability and agility are the objectives you want to achieve with flexibility and that reusability, scalability, modularity and maintainability are ways that can help to achieve the objectives.

#### Conclusion

The definitions of flexibility collected during this research show us that flexibility has to do with preparation for change. As mentioned before organizations are constantly subject to change. Organizations can prepare themselves by taking measures and actions that facilitate change. This makes it easier for them to respond when changes actually take place.

In the introduction section of this research the following definition was proposed based on a search in online dictionaries (see 1.1.2.):

"Flexibility is the ready capability of Enterprise Architecture to adapt to changing circumstances"

The definitions found during the literature study and the interviews confirm that the Enterprise Architecture is an important element to make flexibility work for organizations. Furthermore, all the related words that were found also refer to change or changes take that place in the environment of organizations. These findings confirm that the definition that was proposed at the start of the research includes the basic concepts of flexibility. This research proposes to use this definition of flexibility in the context of Enterprise Architecture.

Furthermore, during the literature study and interviews several words were found with a relationship to flexibility. These words were often used in the context of flexibility. The words

that were collected from the literature and the interview are shown in table 2. A description of the relationship of the words to flexibility is included:

Related word	Relation with flexibility
Scalability	Scalability can be used in the architecture of systems to make them
	more flexible for future use. For example if an organization is not sure
	how many users will use a system a scalable approach can help to
	deal with this uncertainty.
Reusability	By applying reusability concepts in systems design organizations can
	save development costs and at the same time they are put in a position
	to make faster delivery possible when new business needs arise. In
	most of the cases only minor new development is needed. The
	flexibility is created by making re-use of existing components.
Maintainability	Maintainability is the degree to which a software system can be easily
	maintained. It set requirements for modularity, replacement of
	components and diagnostics. Higher maintainability leads to more
	flexibility. For example easier replacement of components in case of
	defects.
Modularity	Modularity is a systems concept and describes the degree to with the
	system components can be separated and recombined and used in
	other systems. Modularity makes systems more flexible if changes
	occur new modules can be added or existing modules can be replaced.
Adaptability	Adaptability is the ability of a system to adapt itself to changing
	circumstances.
Agility	The ability of a system to quickly respond to change.
Loose coupling	Loose coupling reduces the dependencies between systems to
	minimize the impact of changes. In this way loose coupling creates
	flexibility in case of changes
Interoperability	Interoperability is about the sharing of data and making information
	exchange more easier. Interoperability creates flexibility in the sharing
	of data.
Discoverability	Discoverability is ability of information and data to be found. If
	information and data are discoverable they can be used for various
	purposes and increases the flexibility
Governance	Governance is needed to ensure that the whole organization
	contributes to the flexibility of the organization.
Open interfaces	Systems with open interfaces use standards to interact with each other.
	The flexibility that open interfaces result in is that organizations don't
	have to depend on one single supplier but can use other suppliers and
	systems.
Resiliency	Resiliency is the capability of a system to recover form an interruption
	i.e. hardware failure or power loss. This makes the system flexible
	because it's prepared to overcome these kind of failures.

Table 2: Explanation of related words to flexibility

Based on the findings we can conclude that flexibility is indeed a concept that may be difficult to define by organizations. It is often used in combination with other words. The results show us that the related words can either be flexibility characteristics, objectives or measures.

The overall conclusion is that flexibility is difficult to define it depends on the context it's used in. So to make flexibility work organizations should set clear definition and objectives for flexibility. The proposed definition of this research may be used to operationalize flexibility in Enterprise Architecture. Depending on the goals that an organization want to achieve objectives can be formulated and included in the Architecture Vision.

In the next paragraph the important elements of Enterprise Architecture will be described.

## 4.2 Important elements of Enterprise Architecture

Since this research is focused on Enterprise Architecture and flexibility it is relevant to know which elements of Enterprise Architecture are seen as the most relevant ones. This paragraph describes the results from the literature and the interviews. First the findings from the literature and interviews will be presented followed by a conclusion.

#### **Results from literature**

The Enterprise Architecture approach of Op 't Land et al., (2008) indicate that principles are an important element of Enterprise Architecture. Ross et al (2006) agree on this and argue that the architecture principles can be seen as a management mechanism. If organizations have defined clear guiding principles, they will help organizations to generate strategic benefits from the enterprise architecture.

Ross et al (2006) also describe in their paper that many organizations lack clarity in their principles. Unclear architecture principles make it difficult for organizations to design IT and processes that support the organizations operating model. They also mention that effective architecture principles have a relationship with the three characteristics of organizations that are well performing. These three characteristics are:

- Greater architecture involvement of senior management
- Architecture built into project methodology.
- Greater architecture maturity

A lot of literature that was analyzed during the literature study indicated the importance of the architecture principles. Other literature that describes the important elements of Enterprise Architecture was not found. Braun and Winter (2007) describe five essential architecture layers: business architecture, process architecture, application architecture, software architecture and technology architecture.

#### Results from interviews

To collect the information from the interviews, we formulated the following question:

#### INTERVIEW QUESTION:

What are the most important elements of the Enterprise Architecture?

Figure 15 shows the elements that the interviewees mentioned as most important elements of Enterprise Architecture:



Figure 16: Important elements of Enterprise Architecture

The five most important elements based on the interviews are:

#### Principles (28%)

The most important element of Enterprise architecture regarding the interviewees is principles. Based on the literature study we found out that principles describe rules and guidelines that help an organization to achieve its mission. The interviewees indicated that especially the principles which give direction an contribute to grow to a SOLL situation are the most important ones.

#### Architecture blueprint (11%)

And architecture blueprint describes the current state architecture and the step that have to be taken to grow towards a desired target architecture.

#### IST Architecture (11%)

The IST architecture describes the current state of the architecture. IST architectures are also called As-Is architectures.

#### SOLL Architecture (11%)

The SOLL architecture describes the future state of the architecture. SOLL architectures are also called target architectures or To-Be architectures. They describe the architecture that an organization wants to achieve.

#### Communication (11%)

Communication of Enterprise architecture is another important factor that was mentioned by the interviewees. To make the architecture work it has to be communicated.

In paragraph 3.2.1. the Architecture Maturity model of Ross et al (2006) was described. The model showed that the (global) flexibility of an organization increases during the maturity stages. To collect the information from the interviewees about the current maturity level of the Enterprise Architecture of their organizations we formulated the following question:

#### INTERVIEW QUESTION:

Can you describe the maturity level of Enterprise Architecture within your organization?

Since four of the architects that were interviewed work within the same organization the results are merged in organization 1. The results are presented in figure 17



Figure 17: Enterprise Architecture maturity

The figure shows that the Enterprise Architecture of most of the organizations that were interviewed is not so mature. The interviewees mentioned various reasons why they think that the Enterprise Architecture of their organization is not so mature. The reasons included that the architects have limited influence in the organization and that the governance was not properly set.

To get the interviewees opinion on how flexible their organizations are the following question was asked:

#### INTERVIEW QUESTION:

Can you describe how flexible your (organization and) Enterprise Architecture is?

Most of the interviewees indicated that in their opinion the organization is not so flexible, because there are still a lot of legacy systems in use that are difficult to change. The organizations are working on different aspects to create more flexibility. They are working on topics like service orientation, layered architecture and loose coupling of systems.

#### Conclusion

The results from the literature study show us that one of the most important elements of Enterprise Architecture are the principles. This is confirmed by the interview results, a majority of the interviewees indicated that architecture principles are important elements of architecture in organizations. We agree on the importance of architecture principles, our additional opinion on this is that the architecture principles must be understood and interpreted by the different layers of the organization to have the desired effect. To do so the architecture principles must be translated in such a way that it becomes clear what the intention of a certain principle is. Next to the principles the following architecture layers are important: business architecture, process architecture, application architecture, software architecture and technology architecture.

Other important elements of Enterprise Architecture that were collected by the interviews are:

- Architecture blueprint
- IST Architecture
- SOLL Architecture
- Communication

The important elements of Enterprise Architecture that were gathered by the literature study and the interviews are valuable and can be used in the creation of the final model.

The Architecture maturity model that was introduced before in paragraph 3.2.1 describes 4 maturity levels: business silos, standardized technology, optimized core and business modularity. The model suggest that that the more mature the architecture in an organization is, the more global flexibility is being created. The results of the interviews show us that most of the interviewees indicated that the architecture maturity within their organization is not very high. The results on the question "can you describe how flexible your (organization and) Enterprise Architecture is?" show that most of the interviewees don't find their organization so flexible. This aligns with the model of Ross et al (2006) that organization in the lower Enterprise Architecture maturity stages have less global flexibility and more local flexibility.
## 4.3 Identify driving forces for flexibility

The introduction chapter mentioned that organizations have to deal with changing factors in their environment. And paragraph 4.1 described that *flexibility needs* arise to be able to respond to foreseen and unforeseen changes that occur in the environmental context of organizations. This paragraph will present the factors that trigger the need for flexibility, we will call them *driving forces for flexibility*. First the findings from literature will be presented followed by the results from the document review and the interviews. Based on the overall findings a conclusion will be drawn.

#### **Results from literature**

Li et al., (2006a, b) state that organizations in emerging countries are having a hard time due to rapid technology changes and at the same time have to deal with decreased availability of resources. Tatikonda and Rosenthal (2000) argue that the decreased resource availability has to do with the fact that organizations cannot redeploy their resources. Because of this organizations often have difficulties to adapt new products and respond to changes. Organizations are constantly influenced by different factors like economic market changes, change of the political landscape and technology changes. Some of these factors are more predictable than others. When these factors change, organizations and their environment are affected, as a result organizations feel the need to adjust themselves to these changes in a quick and easy manner to ensure business continuity and keep their competitive advantage. For this reason, a lot of organizations are searching for ways to make themselves as resistant as possible to cope with changes that occur in their environment. This is also where the term flexibility often arises. Flexibility is not a new concept; it has been researched in business by economists for over 60 years. The early focus of research was on the ability of a production facility to produce something other than originally intended. (Golden, W., & Powell, P., 2000). This refers to the capability to reuse workers, systems, applications and technology to support the development of new products. The resources of organizations are usually selected. developed and purchased to fulfil a specific task. For example, a production plant is built to produce one single type of light bulb. Introduction of new technology makes light bulbs more sustainable by using LED technology. As an effect customers will buy more LED bulbs and less traditional bulbs. The company will feel the need to adjust their production line as quickly as possible to cope with this change. If they have to buy a whole new production line, because they cannot reuse the old one it will be a very costly transition and will take a lot of time. But when only a part of the production line has to be adjusted to produce both the traditional and LED bulbs the company can make the switch more easily and produce different types of light bulbs based on the market demand.

The "light bulb" example makes clear that the introduction of new technology triggers new business needs. Besides new technology there are more factors that trigger the need for flexibility. In today's world an increased number of business processes and tasks are supported by IT-technology. Based on the coding of the literature (see 2.1.4) factors that trigger the flexibility needs of organizations were collected, analyzed and coded. The overall theme that was created for the coding was: *Why flexibility*. The related sub-codes that were identified are shown in the table below.

Code	Number of codes
Policy changes	9
Changing environment	12
Complexity	5
Innovation	13
Economy	8
Changing requirements	17
Changing circumstances	9
Uncertainty	9
Faster time-to-market	15

The total list of driving forces collected from the literature can be found in table 3.

Table 3: Flexibility driving forces derived from the literature

Table 3 with the driving forces collected from the literature shows that changing requirements and faster time-to-market are the top most driving forces that trigger the need for flexibility. Followed by innovation and the changing environment.

The driving forces will be briefly described:

#### Policy changes

Usually organizations are informed in advance about (possible) policy changes in the future. But when an organization decides to actually implement policy changes, the changes usually remain unclear till the last moment. And if an actual decision to implement a new policy is made, the related processes and information systems must be adjusted quickly.

#### Changing environment

Organizations have to deal with a changing environment. The internal and external environment of organizations are constantly subject to change.

#### Complexity

Complexity is about that making changes to systems is difficult because they are complicated and hard to understand.

#### Innovation

Innovation is about the introduction of new technology. Introduction of new technology can lead to changing requirements or "innovation driven by technology".

#### Economy

Economy is about the market changes that take place in the organizational environment.

#### Changing requirements

Changing requirements is about changing business needs and requirements.

#### Changing circumstances

Changing circumstances are about all sort of changes that take place

#### **Uncertainty**

Uncertainty is about if and when changes will actually take place.

#### Faster time-to-market

Faster time-to-market is about that organizations have to deliver faster. It's about the time taken to develop new products of deliver new services requested by the business.

#### **Results from interviews**

Based on the *flexibility needs* collected from the literature interview questions were formulated to collect additional information from the interviewees:

#### INTERVIEW QUESTION

Is flexibility an important aspect for your organization?



Figure 18 shows that almost all the interviewees agreed upon that flexibility is an important aspect for their organization. They gave various reasons:

- Projects, innovations and policy changes require a flexible approach
- Especially the external flexibility is important
- It is a prerequisite, like phased, structured and isolated.

Next to the flexibility objectives that were collected by the literature study the following question was asked during the interviews to collect additional driving forces from the interviewees.

#### INTERVIEW QUESTION:

Why is flexibility needed within your organization? (Rapid changes, innovations, policy changes etc.)

The total list of driving forces collected from the interviews can be found in table 4

Code	Number of codes
Innovation	4
Policy changes	13
Faster time-to-market	2
Changing requirements	3
Economy	1
New codes	Number of codes
Cooperation with others	7
Short term projects	2

Table 4: Flexibility driving forces derived from the interviews

The interview results show us that policy changes are seen as the most common driving force that trigger the need for flexibility. Next to policy changes the increasing cooperation with others and innovation have a high score. This has to do with that the interviews conducted for this were done within governmental of semi-governmental organizations. Within these organizations cooperation with others is an actual topic at the moment.

#### Conclusion

The results from the literature review and the interviews show us that a clear distinction can be made between internal and external driving forces. Internal driving forces come from within the organization and external driving forces from the outside of the organization. The collected driving forces for flexibility are categorized in table 5. The driving forces are ranked on the amount of codes in descending order.

The collected *driving forces* from the literature and the interviews align with what was mentioned in paragraph 4.1.

The driving force, changing circumstances that was collected from the literature is a global driving force that has to do with all the other collected driving forces. For this reason this driving force will not be included in the total list of driving forces.

Driving force	Internal/ Both/ External	Total codes
1. Changing requirements	Both	20
2. Policy changes	External	19
3. Innovation	External	17
<ol><li>Faster time-to-market</li></ol>	Both	17
5. Changing environment	Both	12
6. Uncertainty	Both	9
7. Economy	External	9
8. Cooperation with others	External	7
9. Complexity	Internal	5
10. Short term projects	Both	2

Table 5: Total list of driving forces for flexibility

The total list of driving forces shows that the top 4 driving forces that trigger flexibility are: Changing requirements, Policy changes, Innovation and Faster time-to-market. The driving forces are driving forces on high level extracted from the literature and the interviews. The identified driving forces are used as input to build the flexibility implementation model.



Figure 19: Flexibility implementation model: Step 1

Now that the first step *Identify driving forces of flexibility* is completed we move on to the second and third step *Define As-Is architecture* and *Determine desired flexibility*.

## 4.4 Determine desired flexibility

In the previous paragraph we identified the *driving forces of flexibility*. In this paragraph the findings on how organizations can determine the desired flexibility will be presented. First the findings from the literature will be described followed by the results from the interviews. Based on the overall findings a conclusion will be drawn.

#### **Results from literature**

#### As-Is architecture

To determine the desired flexibility organizations should first get a clear understanding of the current state of the architecture. As Bailey, I (2006) mention in his paper As-Is architectures are created to get insight in the dependencies within an enterprise and to get an overview of the current architecture.

#### Flexibility objectives

Koornhof (2003) argue in their paper that if organizations want to develop flexibility they should scan their environment in order to recognize the nature and pace of change. By scanning the internal and external environment organizations are able to identify the *driving forces for flexibility* as described in the previous chapter. Based on the driving forces flexibility objectives can be formulated. Koornhof (2003) propose the following approach for developing flexibility indicators.



#### Figure 20: Steps to developing flexibility indicators Koornhof (2003)

According to Koornhof (2003) the first step that should be taken is to identify the type of uncertainty the organization has to deal with. Based on the type of uncertainty strategic objectives can be formulated to deal with the uncertainty. Next flexibility requirements are defined which will support the strategic objectives. The effectiveness can be measured by setting performance objectives and flexibility indicators. See figure 20.

Egyedi et al (2005) agree with the fact that that organizations should pursue certain objectives. In their paper they focused on systems flexibility and identified the general objectives of systems flexibility as shown in table 6.

Objective
Improvement while preserving earlier
investments
Reduced engineering efforts
Reduced operational costs
Higher system efficiency
Reduced maintenance efforts
Table 6: Elexibility objectives from literature

Furthermore, Egyedi et al (2005) state in their paper that *Reusability* is an overarching aim of systems flexibility and that it is an element in all of the flexibility objectives related to ICT as shown in table 7.

Exchangeability	Exchangeability is about exchangeable software applications, hardware components. The reusability is
	focused on reuse in other system or in another context.
Portability	Portability refers to hardware and software platforms on which software can operate and be ported. The reusability is focused on reuse on different platforms;
Scalability	Scalable software has the possibility to run on small and
	large devices. The reuse here is focused on the use in small and large systems.
Extendibility or upgradeability	Extendibility and upgradeability is about adding new
	components to a system and reusing existing
	components of the system to extend the life cycle.
Integration	Integrations is about the reuse of components of a system
	by integration of new elements or different subsystems.
Interconnectivity	Interconnectivity is refers to the reuse of a system through coupling with other systems. This systems can be either internal of external.
Reversibility	Reversibility is about reversing changes to system or software.
Downgradeability	Downgrade able systems make it possible to switch back to older versions of a system

L \_\_\_\_\_ Older versions of a system. Table 7: Flexibility objectives related to ICT by Egyedi et al (2005)

#### **Results from interviews**

Based on the findings in the literature we formulated the following interview question to collect additional objectives from the interviewees:

• What do you want to achieve with this flexibility in EA?

The following list of flexibility objectives was collected from the interviews:

Objective
Reduce costs
<u> </u>
Isolation of problems
Continuity
Agility
Faster time-to-market
Degdeglydg / / / / / / / / / / / / / / / / / / /
(Dereik/Ales///////////////////////////////////
Table 8: Elevibility objectives from interviews

Table 8: Flexibility objectives from interviews

In the table above "Separated layers", "Decoupling" and "Generic layers" are more measures than objectives. We will exclude these flexibility measures from the total list of flexibility objectives. The measures will be included in paragraph 4.5.

The flexibility objectives from the interviews show that one of the flexibility objectives is reduce costs. Costs reduction can be achieved by flexibility. For example by introducing the concepts modularity and reusability. Components of modular systems are easy to exchange or replaced. Reusable components can be reused and save development costs. Isolation of problems was also mentioned as an objective. In case of modular systems one module may fail but the others will still work. In this particular case the system has more flexibility to deal with problems than a legacy system which has no modularity. Continuity was another flexibility objective that was mentioned. Flexibility can contribute to the continuity, for example by introducing a virtualization platform with a failover. If one server fails the application or systems will still work. Another flexibility objective that was mentioned during the interviews was Agility. Flexibility can also lead to agility, if the systems of an organization are scalable and modular and easy to change they may facilitate agility. The last objective that was mentioned in the interviews was faster-time-to-market. The business requires fast delivery of services, solutions and adoption of new technologies. The introduction of flexibility may help organizations to deliver faster. Organizations may introduce different types of flexibility like modular systems and applications in this way adjustments based on changing requirements can be implemented more easily.

#### Conclusion

Summarizing, to determine the desired flexibility organizations should take the *driving forces of flexibility* either predictable or uncertain as a starting point to formulate the *flexibility objective(s)*. The *flexibility objectives* together with the *As-Is architecture* can help organizations to identify the parts in the architecture where flexibility is desired and should be introduced. The *As-Is architecture* and the identified spots where flexibility is desired form the basis to take flexibility measures and for formulating a *To-Be architecture* or *Target architecture*.

The As-Is architecture together with the flexibility objectives is valuable input to set up a To-Be architecture.

Flexibility objective	Explanation
Improvement while preserving earlier	The goal of this objective is adjust systems
investments	to improve them when needed. (i.e. use of
	modular systems.)
Reduced engineering efforts	The goal of this objective is to use reusable
	modules and components to reduce
	engineering efforts.
Reduced operational costs	The goal of this objective to reduce the
	operational cost. (i.e. use virtualization to
	reduce servers)
Higher system efficiency	The goal of this objective is to achieve higher
	systems efficiency. (i.e. use of modules to
	and loose coupling)
Reduced maintenance efforts	The goal of this objective is to reduce the
	maintenance efforts of systems (i.e.
	becomes easier with components and
	modules)
Isolation of problems	The goal of this objective is to reduce the
	impact of change of failures. (i.e. when one
	module has to be changed or fails the other
	modules are not impacted). Next to this
	systems could be adjusted more easily.
Continuity	The goal of this objective is to ensure the
	continuity of systems. (i.e. by using
	virtualization to increase system availability)

Table 9 shows the total list of *flexibility objectives* gathered from the literature and the interviews:

Agility	The goal of this objective is the quick
	response to changes. (i.e. a scalable system
	can adapt easily to increased usage)
Faster time-to-market	The goal of this objective is faster delivery in
	case of new of changing business needs.
	(i.e.by the use of reusable components)
Reduce costs	The goal of this objective is to reduce costs.
	(i.e. use of modules, reusable components
	etc.)

Table 9: Total list of flexibility objectives

A lot of the flexibility objectives that were collected during the research are related to efficiency and cost reductions.



Figure 21: Flexibility implementation model: Step 2 and 3

After step 2 and 3 the flexibility measures will be described in the next paragraph.

## 4.5 Selection of flexibility measures

The previous paragraph described how organizations can determine the desired flexibility. In this paragraph the *flexibility measures* will be presented. First the findings from the literature will be described followed by the results from the document review and the interviews. Based on the overall findings a conclusion will be drawn at the end of this paragraph.

#### **Results from literature**

In paragraph 1.5 was mentioned that most of the previous research on flexibility within Enterprise Architecture was related to Service Oriented Architecture (SOA). This was also confirmed during the literature study. The term SOA was frequently associated with flexibility and Enterprise Architecture in the reviewed literature. SOA is a framework that supports organizations to integrate business processes with the IT infrastructure by the use of standardized components and services that can be reused and combined to support changing business priorities. (Joachim et al, 2013)

Organizations implement SOA for certain reasons. Yoon and Carter (2007) researched what drives the use of SOA. They mention the following reasons in their paper: it facilitate better integration of systems, improvment of data flows, improving customer service and reductions of IT costs. Some other reasons include that the introduction of SOA can facilitate quicker IT responses to market changes and costumer demands and reuse already implemented functionality.

Some of the reasons for implementing SOA that are mentioned above align with the *driving forces* that were described in paragraph 4.3.

Yoon and Carter (2007) mention another benefit of SOA in their paper namely, that it increase of flexibility. They explain in their paper that the introduction of SOA facilitates the reuse of previous developed modular services and that these can be locally extended if business needs change or new business needs arise. Braun et al (2007) agree on this by arguing that adaption an implementation of SOA by organizations can enhance flexibility by the adaptability of foreseen changes and also agility for the unforeseen changes. Abelein et al, (2009) have researched what the most important benefits of SOA are, they identified agility and reuse as the most important benefits.

Measures	Description
Modularity	Modular services, business processes
	and systems
Reuse of functionality	Reuse of already available functionality
Loose coupling	Loose coupling removes the hard connections to increase the ability to change
Standardized components	Use of standards to create a common baseline for cooperation between parties
ESB	ESB simplifies the communication between service providers and service recipients.

The following characteristics and measures of SOA have to do with flexibility and were identified in the literature:

Table 10: Flexibility measures from SOA literature

West (2003) indicated in their paper that the use of open source software provides more flexibility that using proprietary solutions.

The following measures were also collected by literature:

Measures	Description
Open source	Open source refers to source code from software that is available for modification and use.
Interoperability	Interoperability is about the sharing of data and making information exchange easier.
Standard interfaces	Standard interfaces for communication between systems.
Cloud solutions	Cloud solutions provide shared resources and to computers and other devices on demand

Table 11: Flexibility measures from literature

#### **Results from document review**

The available architecture documents within the Rijkswaterstaat Centrale Informatie voorziening see Appendix A, were reviewed to collect flexibility measures. The flexibility measures that where derived from the document review are shown in table 12.

Dutch	English
Centrale opslag gebruikersdata (Bron:	Centralized data storage. (Source: 20110404
20110404 Architectuur TI 2015 v1.08,	Architectuur TI 2015 v1.08, 2.2.9)
2.2.9)	
Any Device en Web-based (Bron:	Any Device and Web-based (Source:
20110404 Architectuur TI 2015 v1.08,	20110404 Architectuur TI 2015 v1.08,
2.2.11)	2.2.11)
Standaardplatformen (Bron: 20110404	Standard platforms (Source: 20110404
Architectuur TI 2015 v1.08, 3.2.4)	Architectuur TI 2015 v1.08, 3.2.4)
Toepassing van virtualisatie technieken	Applying virtualization technology (Source:
(Bron: 20110404 Architectuur TI 2015	20110404 Architectuur TI 2015 v1.08, 3.2.8)
v1.08, 3.2.8)	
Virtualisatie van applicaties (Bron:	Virtualization of applications (software)
20110404 Architectuur TI 2015 v1.08,	(Source: 20110404 Architectuur TI 2015
3.2.8)	v1.08, 3.2.8)
Virtualisatie van servers (Bron: 20110404	Virtualizations of servers (hardware)
Architectuur TI 2015 v1.08, 3.2.8)	(Source: 20110404 Architectuur TI 2015
	v1.08, 3.2.8)

Table 12: Flexibility measures from document review

#### **Results from interviews**

To collect more flexibility measures the following interview question was formulated:

• Is this flexibility a part/ integrated in your Enterprise Architecture? (which measures are taken in the Enterprise Architecture?)?

The measures in table 13 were collected by the interviews. Some of the measures are nearly the same as the measures that were collected form the literature. Similar concepts are reuse and standardization. The measures vary from high level to more detailed measures.

Measure	Description
Separated layers	Separated layers
Loosely coupled components	Loosely coupled components have no
	hard connections and increase the
	ability to change.

Use of services	Services are used to deliver certain functionality an can be reused in applications.
Standard platform	A standard platform is a standardized platform used to simplify information and data haring.
Central connection point	A central connection point is a general interface that is used to connect different organization with each other.
Publish-Subscribe architecture (decoupling)	A publish-subscribe architecture is a message pattern the receivers only receive messaged they subscribed on.
SOA	SOA or Service Oriented Architecture is a architectural pattern based on service- orientation.
Generic layers (Infrastructure)	Generic layers are layers which use standardized technology.
Re-use of components	Reuse of component in other systems.
Decoupling	Decoupling is about that there are no hard connections between interfaces of systems.

Table 13: Flexibility measures from interviews

#### Conclusions

Table 14 shows the total list of collected flexibility measures from the literature, document review and the interviews.

Flexibility measures from	Flexibility measures from	Flexibility measures from
literature	interviews	document review
<ul> <li>Modularity</li> <li>Reuse of functionality</li> <li>Loose coupling</li> <li>Standardized components</li> <li>Open source</li> <li>ESB</li> <li>Cloud solutions</li> <li>Standard interfaces</li> <li>Interoperability</li> </ul>	<ul> <li>Separated Layers</li> <li>Loosely coupled components</li> <li>Use of Services</li> <li>Standard platform</li> <li>Publish-Subscribe Architecture (decoupling)</li> <li>SOA</li> <li>Generic layers (Infrastructure)</li> <li>Re-use of components</li> <li>Decoupling</li> </ul>	<ul> <li>Centralized data storage.</li> <li>Any Device en Web- based</li> <li>Standard platform</li> <li>Applying virtualization technology</li> <li>Virtualization of applications (software)</li> <li>Virtualizations of servers (hardware)</li> </ul>

Table 14: Total list of collected flexibility measures



Figure 22: Flexibility implementation model: Step 4

## 4.6 Proposed flexibility implementation model

In the previous paragraphs the steps to identify driving forces, determine flexibility needs and selection of flexibility measures were described. In this paragraph we will integrate all the steps into a flexibility implementation model.

In paragraph 3.2.4. a process implementation model for organizational flexibility was described. To make flexibility work for organizations and achieve the desired objectives a good implementation of flexibility within the whole organization is necessary. The people within and the stakeholders outside the organization must understand what flexibility means for the organization and how they can contribute to the flexibility objectives.

Implementation of flexibility is more than only implementation of flexibility measures in the Enterprise Architecture. By only taking flexibility measures in the architecture and systems you are not there yet. People have to understand what the organization wants to achieve with flexibility and how they can contribute to it. Therefore communication is an important aspect when implementing flexibility.

In the table below the different steps of the implementation model are linked to the ADM phases of TOGAF. The steps begin at the bottom of the table.

Step	TOGAF ADM phases		
6. Evaluate			
5. a) To-Be architecture	Phase B: Business Architecture		
b) Implementation proces	Phase C: Information Systems Architecture		
	Phase D: Technology architecture		
	Phase E: Opportunities and Solutions		
	Phase F: Migration planning		
	Phase G: Implementation Governance		
	Phase H: Architecture Change Management		
4. a) Evaluate existing measures	Phase B: Business Architecture		
<ul> <li>b) Adjust flexibility measures</li> </ul>	Phase C: Information Systems Architecture		
<ul> <li>c) Select flexibility measures</li> </ul>	Phase D: Technology architecture		
3. Determine flexibility objectives	Phase A: Architecture Vision		
	Phase B: Business Architecture		
	Phase C: Information Systems Architecture		
	Phase D: Technology architecture		
2. Define As-Is architecture	Phase B: Business Architecture		
	Phase C: Information Systems Architecture		
	Phase D: Technology architecture		
1. Identify driving forces	Phase A: Architecture Vision		
	Phase B: Business Architecture		
	Phase C: Information Systems Architecture		
	Phase D: Technology architecture		

#### Step 1: Identify driving forces

The first step is to identify the internal and external driving forces for flexibility. Organizations can use a PESTEL analysis to identify the external driving forces from different factors. The driving forces are valuable input for the organizations Architecture Vision. In this step the following TOGAF ADM Cycle Phases are relevant: A, B, C and D.

See Appendix F for an overview of the driving forces collected during this research.

#### Step 2 Define As-Is Architecture

After the driving forces are described In the organizations Architecture Vision an As-Is Architecture or Baseline Architecture as defined in TOGAF should be defined to get a clear understanding of the current state of the architecture. The As-Is architecture has to be formulated for all 3 architecture layers (Business Architecture, Information Systems Architecture, Technology architecture). In this step the following TOGAF ADM Cycle Phases are relevant: B, C, and D.

#### Step 3 Determine flexibility objectives

Based on the driving forces flexibility objectives should be formulated. The flexibility objectives should be described in the Architecture Vision and for each architecture layer (Business Architecture, Information Systems Architecture, Technology architecture). In this step the following TOGAF ADM Cycle Phases are relevant: A, B, C and D.

See Appendix F for an overview of the flexibility objectives collected during this research.

#### Step 4a Evaluate existing measures

The next step is to evaluate the existing flexibility measures that are in place before selecting new flexibility measures. The existing flexibility measures should be evaluate on each architecture layer (Business Architecture, Information Systems Architecture, Technology architecture).

In this step the following TOGAF ADM Cycle Phases are relevant: B, C, and D.

#### Step 4b Adjust flexibility measures

After the evaluation it may be needed to adjust the existing flexibility measures so that they align with the flexibility objectives.

In this step the following TOGAF ADM Cycle Phases are relevant: B, C, and D.

#### Step 4c Select flexibility measures

Based on the As-Is architecture and the flexibility objectives new flexibility measures can be selected for the organization. This should be done for each architecture layer (Business Architecture, Information Systems Architecture, Technology architecture). In this step the following TOGAF ADM Cycle Phases are relevant: B, C, and D.

See Appendix F for an overview of the flexibility measures collected during this research.

#### Step 5a To-Be Architecture

The points in the As-Is Architecture where flexibility measures should be introduced must be identified. The flexibility measures with the indicated points serve as input to set up a To-Be or Target Architecture as defined in TOGAF. These activities match with the following phases of the TOFAG ADM cycle Business Architecture, Information Systems Architecture and Technology architecture which include setting up a Target Architecture and performing a gap analysis. In this step the following TOGAF ADM cycle Phases are relevant: B, C, D and E are relevant.

#### Step 5b Implementation process

To ensure that the organization will pursue the flexibility objectives that are set in step 3 an implementation process is needed. The focus in this step is on the governance and the communication. The architecture vision and the flexibility objective will be communicated to create awareness within the organizations. Furthermore in this step actions are formulated that make a contribution to realize the To-Be architecture and the flexibility objectives. The governance must be in place to ensure the conformance with the To-Be Architecture. New projects may be formulated and existing projects can be used to make a contribution. In this step the following TOGAF ADM Cycle Phases are relevant: F, G, and H.

#### Step 6 Evaluate

Over time the flexibility objectives and the flexibility measures should be evaluated to determine if they have the desired effect. This enables the adjustment of the flexibility objectives and measures.

Applying CIMO logic can help organizations to determine which flexibility objectives and measures in the EA should be introduced to minimize the impact of the driving forces.

_	
Evam	nla
Lvan	pie.

Context	Increasing cooperation with other partners and less financial resources for new developments
Intervention (s)	Create agreements to standardize the way of collaboration and stimulate reuse of already available building blocks at either partner.
EA Measure(s)	Define principles for re-use of components Use of open standards Standardization Introduction of an ESB
Outcome (s)	Easier information sharing Less budget needed for the development of new components.

Evaluation

### 5. Integrate flexibility measures in EA

- a) To-Be architecture
- b) Implementation process



Figure 23: Flexibility implementation model: Step 6

## 4.7 Validation of the model

The proposed model in paragraph 4.6 was validated in a validation meeting with experts. The results of the validation are described in this paragraph.

During the validation meeting the results of the research were presented to the group of experts. The experts received a survey with validation questions that they were asked to answer. See Appendix G for the presentation and the list of validation questions. The results of the validation by the experts will be discussed per question.

#### Definition

1. Do you agree on the proposed definition?

Two of the experts agreed on the proposed definition of flexibility. The other expert partly agreed on the definition, because the definition was limited to changing circumstances.

Additional comments of the experts:

"Broad definition, but therefore covers all relevant interpretations"

"EA must provide the means to adapt quickly to changing circumstances"

"I agree, with the definition to a large extent but would not limit to changing circumstances"

#### Important element of EA

2. Do you agree on the important elements of Enterprise Architecture?

All the experts agreed on the important elements of Enterprise Architecture.

Additional elements mentioned by the experts:

- Information architecture layer
- Data architecture layer
- Organization of your business
- Transition architecture

#### Flexibility implementation model

3. Do you find the steps in the model logical steps?

All the experts agreed on that the proposed flexibility implementation model consist of logical steps.

Additional comments of the experts:

"Logical steps, especially step 3 is important"

"The steps nicely follow the ADM Cycle and taking the right architecture layers and vision into account"

"Although an architect will transform the model to have the TOGAF ADM Cycle phases as leading"

4. Do you think that the model can be useful?

All the experts agreed on the usefulness of the model.

Additional comments of the experts:

"Step 3 forces you to define what flexibility means for your organization"

"It's a structured method to determine flexibility"

5. Are there steps missing in the model?

Two of the experts answered that there are no steps missing. One expert mentioned that there may be a step missing between step 3 and 4 or between 4 and 5.

Additional comments of the experts:

"Where do you test your new measures"

"Add something about the costs of the measures versus the gain"

"Missing the link between the objectives and measures"

#### Flexibility driving forces

6. Do you recognize the driving forces?

Two experts indicated that hey recognize the driving forces. One experts answered No, because many are to generic to be a specific driving force i.e. changing environment and changing circumstances.

Additional comments of the experts:

"Is complexity really a driving force for change?"

7. Are there other important driving forces missing? (If so which ones?)

- Technological change

- Social change

#### Flexibility objectives

8. Do you recognize the objectives?

All the experts indicated that they recognize the objectives.

Additional comments of the experts:

"Agility = flexibility?"

9. Are there other important objectives missing? (If so which ones?)

"Be able to comply to policies"

"Are these "flexibility" objectives?"

"Reservation of knowledge (e.g. in people or in knowledge bases)"

#### **Flexibility measures**

10. Do you recognize the measures?

All the experts indicated that they recognize the measures.

- 11. Are there other important measures missing? (If so which ones?)
- Education of people
- Certification of technology

## 5. Conclusion

This chapter will describe the results of the research.

## 5.1 Conclusion

As was mentioned in paragraph 4.1 the word flexibility is not yet well understood because it can be interpreted in different ways and used in different contexts. Furthermore, flexibility is often related to various other words like agility, adaptability and scalability. From the definitions it became clear that flexibility has to do with change and the ability of organizations to respond to the changes that occur in their environment. These findings show us that it is important for organizations to determine what purposes they need flexibility for.

Another result of this research is the identification of the most important elements of Enterprise Architecture. The reviewed literature and the interview results both identified architecture principle as the most important element of Enterprise Architecture. Other important elements of Enterprise Architecture that were identified by this research are architecture blueprints, As-Is architectures, To-Be architectures and communication.

The main result of the research is a proposed flexibility implementation model. This model is described in paragraph 4.6. Below the steps of the model are described briefly.

To make flexibility work for an organization the first step that has to be executed is the identification of what triggers the need for flexibility. In this research this step is defined as *1. Identify driving forces.* In this step organizations scan the internal and external environment to collect the driving forces. The research identified several driving forces of flexibility that can be found in paragraph 4.3 and Appendix F. The main driving forces collected by this the research are changing requirements, policy changes, innovation and faster time-to-market.

After the driving forces of flexibility are identified organizations have to *determine the desired flexibility*. To do so organizations have to execute the following steps. 2. *Define As-Is Architecture:* In this step organizations must define or update their As-Is architecture to get a clear understanding of their current state of the architecture. The As-Is architecture also forms a basis for the identification of spots where flexibility should be introduced. When this step is done organizations can proceed to the next step 3. *Determine flexibility objectives:* In this step organization formulate what they want to achieve with certain flexibility. The As-Is architecture and the flexibility objectives form the basis for the next step.

The next step is step 4. Selection of flexibility measures. In this step organizations should evaluate the existing measures if applicable. The existing measures may be adjusted or new flexibility measures can be selected to align with the flexibility objectives. In the next step 5. *Integrate flexibility measures in Enterprise Architecture* a To-Be architecture should be developed with the input from the previous steps. To ensure that the whole organization contributes to the flexibility objectives, the organization has to follow the implementation process to set the governance and communication. The last step is 6. *Evaluate* in this step the organization evaluates if the flexibility objectives are met and if the flexibility measures that have been taken have the desired effect.

The proposed model was validated by a group of experts in a validation meeting. The general conclusion is that the proposed model may help organizations by the integration of effective flexibility measures in the Enterprise Architecture.

### 5.2 Answering the research questions

In this paragraph the main and sub research questions will be answered.

#### 1) Why is it important for organizations to have flexibility in their Enterprise Architecture?

One of the results of this research is that organizations are constantly impacted by internal and external changes. These changes have different causes. The research shows that flexibility is important for organizations because of different reasons. In this research several driving forces of flexibility were identified, these can be found in paragraph 4.3 and Appendix F.

#### 2) How can organizations determine the desired flexibility?

The results of the research show us that organizations can determine the desired flexibility by scanning the internal and external environment for changes that may occur. When the driving forces for flexibility are clear, the As-Is architecture (current state of the architecture) must be defined to identify the parts where flexibility should be introduced. Furthermore, the driving forces and the As-Is architecture form the basis to formulate flexibility objectives. See paragraph 4.4 and Appendix F.

#### 3) Which Enterprise Architecture measures can be used to reach the desired flexibility?

There are a lot of measures that could be taken in the Enterprise Architecture to fulfil the flexibility needs. The implementation of effective measures depends on the flexibility objectives. The total list of flexibility measures collected by this research can be found in paragraph 4.5 and Appendix F.

#### 5) How should organizations implement the measures in their Enterprise Architecture?

The main objective of the research was to develop a flexibility implementation model. The model can be used by organizations to integrate effective measures in their Enterprise Architecture. The model helps organizations to prepare themselves to be able to respond to changes that occur in their internal and external environment more easily. In paragraph 4.6 the flexibility implementation model is presented.

## 5.3 Limitations of the research

The driving forces that were collected during this research are high level themes of driving forces. Various driving forces were collected both by interviews and literature review. Consequently, they were grouped in different themes during the coding process. The driving forces are too global to take specific measure. Organization have to specify their own detailed driving forces to be able to select the right objectives and measures.

The research mainly focused on the technological and architecture aspects and less on other aspects within organizations that are important to make flexibility work. For example the people, culture and knowledge aspects. These aspects must also be taken into account when implementing organizational flexibility.

For this research only 7 persons were interviewed. Most of the interviewees work within a governmental organization or semi-governmental organization. Therefore, the research results may not be representative and the same for all organizations.

The validation of the research results was done by arranging validation meeting with experts. The same group of experts were already consulted in the interviews. Perhaps it would have been better to consult another group of experts to get an independent opinion about the model.

## 5.4 Suggestions for future research

In future research it would be interesting to apply the model to a practical case to proof if the formulated model will actually work. This could lead to new knowledge and points for further improvement of the model.

Another suggestion for future research would be to try to improve the model by linking the driving forces, flexibility objectives and the measures to each other. This will give more insight in which objectives and measures organizations should implement to deal with specific driving forces.

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## Appendix A: List of reviewed documents

The following Architecture document were available at the start of this research and used as input.

Enterprise Architecture

- 20110404 Architectuur TI 2015 v1.08, 2.2.9
- 1.2 Visie Netwerken en Telefonie v2 4 RWS huisstijl
- 3.2.2 Blauwdruk Netwerk Infrastructuur RWS v1 1 (final)
- 4.2 Roadmap Netwerk Infrastructuur RWS 2010-2014 v1 1 (final)
- Visie op de RWS Informatie- en gegevensarchitectuur def v10

**Domain Architecture** 

• Dienstenplaten Alle clusters v0.6

Solution Architecture

CIV.PSA template.V1.0

## Appendix B: List of EA definitions

**1. ANSI/IEEE Std 1471-2000**: "The fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution."

**2. Cap Gemini**: "Enterprise Architecture is the description and visualization of the structure of a given area of contemplation, its elements and their collaborations and interrelations links vision, strategy and feasibility, focusing on usability durability and effectiveness. Architecture enables construction, defining principles, rules, standards and guidelines, expressing and communicating a vision"

**3. Forrester, Gene Leganza, 2001**: "Enterprise architecture consists of the vision, principles and standards that guide the purchase and deployment of technology within an enterprise"

**4. Gartner Group**: "Enterprise architecture (EA) is the process of translating business vision and strategy into effective enterprise change by creating, communicating, and improving the key principles and models that describe the enterprise's future state and enable its evolution."

**5. Gartner Group, Philip Allega**: "Enterprise architecture is the process that interweaves business and IT together"

**6. Institute for Enterprise Architecture Development**: "Enterprise Architecture is about understanding all of the different elements that go to make up the enterprise and how those elements interrelate"

**7.MIT Center for Information Systems Research**: "Enterprise Architecture is the organizing logic for key business processes and IT capabilities reflecting the integration and standardization requirements of the firm's operating model."

**8.The ArchiMate Foundation**: "A coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organizational structure, business processes, information systems, and infrastructure "

**9.The Open Group**: "By being inclusive with all other management frameworks, EA is a discipline that helps the Enterprise define , develop and exploit the boundaryless information flow (BIF\*) capabilities in order to achieve the Enterprise's Strategic Intent." \*Boundaryless Information Flow is a Trademark of The Open Group

**10.US Federal Enterprise Architecture Framework (FEAF)**: "Enterprise architecture is a management practice to maximize the contribution of an agency's resources, IT investments, and system development activities to achieve its performance goals. Architecture describes clear relationships from strategic goals and objectives through investments to measurable performance improvements for the entire enterprise or a portion (or segment) of the enterprise"

Source: <u>http://www.ariscommunity.com/users/koiv/2009-08-20-10-definitions-enterprise-architecture-which-corresponds-yours</u>

## Appendix C: Interview questions

### **CONTACT INFROMATION:**

Name of organization : E-mailadres: Telephone number:

#### GENERAL

- 1. What is your role/position within the organization?
- 2. How big is your organization?
- 3. What type of organization? (private public sector semi- public sector?)
- 4. How big is the architecture department?
- 5. What are the (primary) business processes within the organization?
- 6. Which applications supports the (primary) business processes? (total amount of applications)
- 7. Size of budget reserved for architecture ["€"]
- 8. What different types of architects exist within your organization? (e.g. Domain-specific architects, Enterprise Architects, Infrastructure architects and security architects?
- 9. How many of each of these types of architects are employed? (internal and external)

#### ENTERPRISE ARCHITECTURE

- 1. How is Enterprise Architecture organized within your organization? (support of decision making, governance etc.?)
- 2. What are the most important elements of the Enterprise Architecture?
- 3. How often is your Enterprise Architecture revised? (What are the reasons for such a revision? Trigger?)
- 4. Do you use an Enterprise Architecture framework? (Which one? Why that one?)
- 5. Can you describe the maturity level of Enterprise Architecture within your organization?

#### FLEXIBILITY

- 1. Is flexibility an important aspect for your organization?
- 2. Why is flexibility needed within your organization? (Rapid changes, innovations, policy changes etc.)
- 3. With what kind of uncertainty does your organization have to deal? And how is this uncertainty managed? (i.e. Roadmapping? Scenario thinking? techniques)
- 4. What kind of future developments (of the organization) are predictable and which are not?
- 5. Can you define "flexibility" in Enterprise Architecture?. (Will be verified with definition extracted from the literature review)
- 6. Is there a clear and unambiguous definition of "flexibility" in Enterprise Architecture used within you organization?
- 7. Can you describe how flexible your (organization and) Enterprise Architecture is?
- 8. Is this flexibility a part/ integrated in your Enterprise Architecture? (which measures are taken in the Enterprise Architecture?)
- 9. Can you give examples in the Enterprise architecture where you need flexibility? (layers of EA)
- 10. What do you want to achieve with this flexibility in the EA?
- 11. What does the organization do to achieve the needed flexibility?
- 12. What do you as [role/position from question 1] do to achieve this flexibility goal?

- 13. Which Enterprise Architecture products did you create/deliver or make a contribution to in the last year? Is the flexibility aspect a part of it?
- 14. Is SOA implemented in your organization? If so can you define what SOA means? Why SOA? For what goal?
- 15. Is standardization a part (i.e. principle) of your Enterprise Architecture? If so, where is this standardization focused on and why?
- 16. What Enterprise Architecture tools are in use to support the Enterprise Architecture. (i.e. Archimate, Aris etc.)

#### Statements

- 1. Flexiblity has to do with: (Add more if possible)
  - a. Scalability (Schaalbaarheid)
  - b. Reusability (Herbruikbaarheid)
  - c. Maintainability (Onderhoudbaarheid)
  - d. Modularity (Modulariteit)
  - e. Adaptability (aanpassingsvermogen)
  - f. Agility (Behenidigheid)
- 2. The Enterprise Architecture of my organization is flexible enough. [Do you agree YES/NO ?] Why or why not? (where do you base this conclusion on?)
- 3. There is a good link between the business and IT department within the organization. [Do you agree YES/NO?] Why or why not?
- 4. An alignment between the Business and IT architectures are a crucial factor for the organizations agility. [Do you agree YES/NO?]
- 5. New systems and application that are created within our organization are designed with the "flexibility to change" the products have the flexibility to evolve and meet new needs. [Do you agree YES/NO?] Why or why not? How does the Enterprise Architecture contribute to this?
- 6. It is not possible to organize Enterprise Architecture in such a way that it can deal with all the uncertainty an organization has to deal with. [Do you agree YES/NO?] Why or why not?
- 7. Flexibility in Enterprise Architecture is needed to be able to respond to changes easily and to adjust to changes in time. [Do you agree YES/NO?] Why or why not?
- 8. Flexibility in Enterprise Architecture is needed to be able to deliver strategic decision information in time to make decisions. [Do you agree YES/NO?] Why or why not?

# Appendix D: E-mails sent to interviewees in Dutch INVITATION FOR INTERVIEW

Beste .....,

Ik zal me eerst kort introduceren:

Ik ben Jaouad Ben Dahman en ben bezig met mijn afstudeeronderzoek ter afronding van de Masterstudie ICT in Business die ik aan de Universiteit Leiden volg. Ik ben daarnaast werkzaam bij de Centrale Informatievoorzieningsdienst van Rijkswaterstaat als Service Delivery Manager. Mijn afstudeeronderzoek richt zich op het vraagstuk "flexibiliteit en Enterprise architectuur" en voer ik uit voor de afdeling OSR Verkeersmanagement Services binnen Centrale Informatievoorzieningsdienst van Rijkswaterstaat. Ik ben momenteel bezig met een literatuuronderzoek en documentenreview om zoveel mogelijk relevante informatie te vergaren over het onderwerp. Vanuit het literatuuronderzoek zal ik vanuit de theorie een eerste beeld kunnen vormen van het onderwerp. Uit het lopende literatuuronderzoek zullen ook nog een hoop vragen komen. Doormiddel van het houden van interviews wil ik mijn bevindingen uit het literatuuronderzoek toetsen aan de praktijk en wil ik daarnaast nog meer relevante informatie verzamelen over het onderwerp.

Volgens mij gegevens ben jij werkzaam in een architectuurfunctie bij

...... Daarom zou ik graag met jou in gesprek willen gaan over het onderwerp "flexibiliteit en Enterprise architectuur" en een interview met je willen afnemen.

Aanpak interview:

- 1) Het interview wordt waar mogelijk gepland in de 2<sup>de</sup> week van september, de inschatting is dat het interview maximaal 1,5 uur zal duren.
- 2) Minimaal 3 dagen voor het interview ontvang je van mij ter voorbereiding de lijst met interviewvragen per mail.
- 3) Het interview zal worden opgenomen om de informatie later te kunnen verwerken. (Met opgenomen data zal vertrouwelijk worden omgegaan de data wordt anoniem verwerkt en zal door andere niet op personen herleidbaar zijn.). Als je hier bezwaar tegen hebt hoor ik dat graag.
- 4) Na het interview zal de verzamelde informatie verwerkt worden en zal dit ter controle aan je worden voorgelegd.

Graag verneem ik van je of je je medewerking wil verlenen aan mijn afstudeeronderzoek. Als je ermee instemt ontvang ik graag jou mogelijkheden om het interview te houden in de 3<sup>de</sup> of 4<sup>de</sup> week van oktober.

Ik verneem graag uiterlijk 20 september een reactie van je als dat mogelijk is, alvast bedankt.

Met vriendelijke groet,

Jaouad Ben Dahman

#### EMAIL SENT TO VALIDATE INTERVIEW DATA

Beste .....,

Bijgevoegd vind je de uitwerking van het interview dat we hebben gehouden in het kader van mijn afstudeeropdracht.

Graag wil ik je vragen om de uitwerking te controleren en waar nodig te verbeteren en aan te vullen.

Het zou mooi zijn als ik je reactie uiterlijk donderdag kan ontvangen dan kan ik het interview namelijk meenemen in de analyse met de andere interview resultaten.

Alvast bedankt.

Groeten,

Jaouad Ben Dahman



Web based

Cloud solution

## Appendix F: Collected flexibility driving forces, objectives and measures



## Appendix G: Presentation and validation survey Presentation

## **Research questions**

#### Main research question:

How can organizations integrate effective measures in their Enterprise Architecture to increase their flexibility?

To be answered by combining the results of subquestions 1, 2 and 3 and by creating a model which will be verified.

#### Sub questions:

- Why is it important for organizations to have flexibility? To be answered by conducting a literature study and interviews.
- 2) How can organizations determine the needed flexibility? To be answered by conducting a literature review.
- 3) Which Enterprise Architecture measures can be used to reach the needed flexibility? To be answered by conducting a literature review and interviews. And by reviewing current architecture documentation.
- 4) How should organizations implement the Enterprise Architecture measures? To be answered by conducting a literature study and interviews.

## Research Method



Proposed definition for flexibility in EA

"Flexibility is the ready capability of Enterprise Architecture to adapt to changing circumstances"

Validation question: 1. Do you agreed on the proposed definition? (why or why not?)

## Important elements of EA

#### Important elements of EA:

- Architecture principles
- Architecture blueprintIST Architecture
- SOLL Architecture Communication
- · PSA
- Architecture Vision
- Business services
- Architecture guidelines

Essential layer of Enterprise Architecture:

- business architecture
- process architecture
- application architecture
- software architecture
- technology architecture

Validation questions: 2. Do you agreed on the important elements of Enterprise Architecture? (If so which ones)

## CIMO Logic, PESTEL and TOGAF ADM



## Proposed flexibility implementation model

	Step	TOGAF ADM phases
6. Evaluation	6. Evaluate	
5. Integrate flexibility measures in EA a) To-Be architecture b) Implementation process	5 a) To-Be architecture b) Implementation proces	Phase B: Business Architecture Phase C: Information Systems Architecture Phase D: Technology architecture Phase E: Opportunities and Solutions Phase F: Migration planning Phase G: Implementation Governance Phase H: Architecture Change Management
4. Measures a) Evaluate existing measures b) Adjust flexibility measures b) Select flexibility measures	<ol> <li>a) Evaluate existing measures</li> <li>b) Adjust flexibility measures</li> <li>c) Select flexibility measures</li> </ol>	Phase B: Business Architecture Phase C: Information Systems Architecture Phase D: Technology architecture
3. Determine flexibility objectives	3. Determine flexibility objectives	Phase A: Architecture Vision Phase B: Business Architecture Phase C: Information Systems Architecture Phase D: Technology architecture
2. Define As-Is architecture	2. Define As-Is architecture	Phase B: Business Architecture Phase C: Information Systems Architecture Phase D: Technology architecture
1. Identify driving forces	1. Identify driving forces	Phase A: Architecture Vision Phase B: Business Architecture Phase C: Information Systems Architecture Phase D: Technology architecture

Validation questions:

3. Are the steps in the model logical logical?

4. Do you think that the model can be useful?

5. Are there steps missing in the model?

#### Step 1: Identify driving forces

The first step is to identify the internal and external driving forces that trigger the need for flexibility. Organizations can use a PESTEL analysis to identify the external driving forces on the different aspects. The driving forces are valuable input for the organizations Architecture Vision. In this step the following TOGAF ADM Cycle Phases are relevant: A, B, C and D are relevant.

#### Step 2 Define As-Is Architecture

After the driving forces are described in the organizations Architecture Vision an As-Is Architecture (or Baseline Architecture as defined in TOGAF) should be defined to get a clear understanding of the current state of the architecture. The As-Is architecture has to be formulated for all 3 architecture layers (Business Architecture, Information Systems Architecture, Technology architecture). In this step the following TOGAF ADM Cycle Phases are relevant: B, C, and D are relevant.

#### Step 3 Determine flexibility objectives

Based on the driving forces flexibility objectives should be formulated. The flexibility objectives should be described in the Architecture Vision and for each architecture layer (Business Architecture, Information Systems Architecture, Technology architecture). In this step the following TOGAF ADM Cycle Phases are relevant: A, B, C and D are relevant.

#### Step 4a Evaluate existing measures

The next step is to evaluate the existing flexibility measures that are already in place before selecting new flexibility measures. The existing flexibility measures should be evaluate on each architecture layer (Business Architecture, Information Systems Architecture, Technology architecture). In this step the following TOGAF ADM Cycle Phases are relevant: B, C, and D are relevant.

#### Step 4b Adjust flexibility measures

After the evaluation it may be needed to adjust the existing flexibility measures so that they align with the flexibility objectives.

In this step the following TOGAF ADM Cycle Phases are relevant: B, C, and D are relevant.

#### Step 4c Select of flexibility measures

Based on the As-Is architecture and the flexibility objectives new flexibility measures can be selected for the organization. This should be done for each architecture layer (Business Architecture, Information Systems Architecture, Technology architecture). In this step the following TOGAF ADM Cycle Phases are relevant: B, C, and D are relevant.

#### Step 5a To-Be Architecture

The points in the As-Is Architecture where flexibility measures should be introduced must be identified. The flexibility measures with the indicated points serve as input to set up a To-Be or Target Architecture as defined in TOGAF. This activities match with the following phases of the TOFAG ADM cycle Business Architecture, Information Systems Architecture and Technology architecture which include setting up a Target Architecture and performing a gap analysis. In this step the following TOGAF ADM Cycle Phases are relevant: B, C, D and E are relevant.

#### Step 5b Implementation process

To ensure that the organization will pursue the flexibility objectives that are set in step 3 an implantation process is needed. The focus in this step is on the governance and the communication. The architecture vision and the flexibility objective will be communicated to create awareness within the organizations. Furthermore in this step actions are formulated that make a contribution to realize the To-Be architecture and the flexibility objectives. The governance must be in place to ensure the conformance with the To-Be Architecture. New projects may be formulated and existing projects can be used to make a contribution. In this step the following TOGAF ADM Cycle Phases are relevant: F, G, and H are relevant.

#### Step 6 Evaluate

Over time the flexibility objectives and the flexibility measures should be evaluated to determine if they have the desired effect. This enables the adjustment of the flexibility objectives and measures if needed.

Driving	Driving forces Objectives		Objectives Measures					
Cooperation with others	Policy changes	Improvement while preserving earlier investments	Reduce costs	Reuseability	Reuseable components / building blocks			
Short time projects	Changing enviroment	Reduced engineering efforts	Isolation of problems	Modularity	Modular Processes	Modular Services	Modular Systems	
Changing requirements	Complexity	Reduced operational costs	Continuity	Virtualization	Cloudoplossingen	Vitrualization of applications (software)	Vitrualization of servers (hardware)	
Changing circumstances	Innovation	Higher system efficiency	Agility	Standardization	Use of standard components	Use of Open standards	Standard Platform	Generic layers (Infrastructure)
Uncentrainty	Economy	Reduced maintenance efforts	Faster time-to- market	Interoperability	Standard Interfaces	Use of Open source		
Faster time-to- market				SOA	ESB	Loosely couple components	Use of services	
				Centralized data storage	Publish-Subscribe architecture	Decoupling	Separated layers	

Validation questions:

- 6. Do you recognize the driving forces?
- 7. Are there other important driving forces missing? (If so which ones?)
- 8. Do you recognize the objectives?
- 9. Are there other important objectives missing? (If so which ones?)
- 10. Do you recognize the measures?
- 11. Are there other important measures missing? (If so which ones?)

## Validation questions:

Definition 12. Do you agreed on the proposed definition? Yes No
(Why or why not?)
Important element of EA 13. Do you agreed on the important elements of Enterprise Architecture? Yes No
Are there other important elements missing? (If so which ones?)
Flexibility implementation model 14. Do you find the steps in the model logical steps? Yes No
(why or why not?)
15. Do you think that the model can be useful? Yes No
(why or why not?)
16. Are there steps missing in the model? Yes No
(If so which ones?)

Flexibility	driving	forces

	17.	Do y	ou r	ecogr	nize t	the d	riving	forces	?
Yes	N	lo							

(If No why not?)

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### 18. Are there other important driving forces missing? (If so which ones?)

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#### **Flexibility objectives**

19. Do you recognize the objectives? Yes No

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### (If not why not?)

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20. Are there other important objectives missing? (If so which ones?)


#### **Flexibility measures**

21. Do you recognize the measures?

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#### (If not why not?)

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#### 22. Are there other important measures missing? (If so which ones?)

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