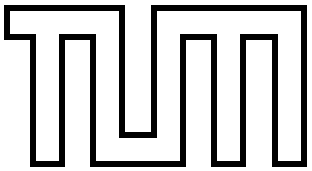

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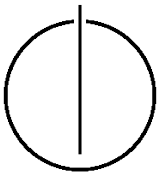
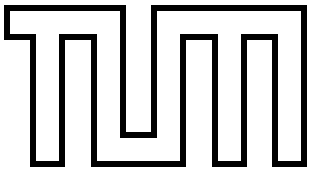
Bachelorarbeit in Wirtschaftsinformatik

Analysis and Classification of Maturity Models in Enterprise Architecture Management

Benjamin Szyszka





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Analysis and Classification of Maturity Models in Enterprise Architecture Management

Analyse und Klassifikation von Reifegradmodellen im Enterprise Architecture Management

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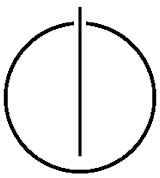

I assure the single handed composition of this Bachelor Thesis only supported by declared resources.

München, den 8. Oktober 2009 Benjamin Szyszka

Abstract

Today, enterprises are faced with the challenges of a highly dynamic marked and environment. A part of the solution to survive in this environment is developing an effective and efficient enterprise architecture management, which provides a holistic approach to align business and IT. However, the enterprises are faced with many difficulties, problems, and high investments during this development. One commonly accepted means improve the enterprise architecture management are maturity models, which provide path for a guided and controlled development of an EA management approach.

This Bachelor Thesis focuses on maturity models for enterprise architecture management. There is a variety of maturity models available in the market. This thesis give an general overview on existing models. Furthermore, an analysis and classification framework is developed. This classification framework can help enterprises by providing aspects for the selection of the most suitable maturity model for an enterprise. In addition, a number of maturity models were classified, analyzed, and compared with the help of the developed framework.

Finally, one model was selected based on the classification with the developed framework for an assessment of the enterprise architecture management approach of an industrial partner. Based on the case study the selection of a maturity model supported by the analysis and classification framework is discussed.

Key Words: *enterprise architecture, enterprise architecture management, maturity model, classification framework, process improvement, process assessment*

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List of Abbreviations

ACMM	Enterprise Architecture Capability Maturity Model
AMM	Architecture Maturity Matrix
CAO	Chief Administrative Officer
CCA	Clinger-Choen Act
CEE	Central and Eastern Europe
CIO	Chief Information Officer
CMM	Capabillity Maturity Models
CMMI	CMM integration
COBIT	Control Objectives for Information and related Technology
COO	Chief Operating Officer
CSO	Chief Security Officer
DoC	Department of Commerce
DyA	Dynamic Architecture
E2A	Extended Enterprise Architecture
E2AMM	E2A Maturity Model
EA	Enterprise Architecture
EAMMF	EA management maturity framework
EOP	Executive Office of the President
FEAF	Federal EA Framework
GAO	Governance Accountability Office
IFEAD	Institute for Enterprise Architecture Developments
IPv6	Internet Protocol version 6.0
ISACA	Information Systems Audit and Control Association
IT	Information technology
ITGI	IT Governance Institute
ITMRA	IT Management Reform Act
KPA	Key process area
KPI	Key performance indicators
NASCIO	National Association of State Chief Information Officers
OMB	Office of Management and Budget
SEI	Software Engineering Institute
SLA	Service-level agreement
SPICE	Software Process Improvement and Capability Determination

1. Introduction and overview

1.1. Motivation

Today the design of the enterprise architecture (EA) in an organization is an important subject. Typically the EA has historically grown with it's organization. Through merge, acquisitions, and partly uncontrolled development the enterprise consist of monolithic systems, which are insufficient aligned to emerging and existing business needs. Organizational requirements like business process transformations, releases of new products, and operation of projects become more and more a challenge. As a consequence these changes and innovations are expensive. 2007, an organization spent around 0.9 percent of revenue in *metals and natural resources* sector up to 6.9 percent of turnover in financial service sector in the development and operation of information technology (IT) [Sm09]. Obviously the need for more qualitative, agile systems, and reduced IT costs has increased and therefore the need for a defined EA management process has risen. As in other IT process areas e.g. in development of software the general point of view is that an improvement of product quality is due to an improvement in the process [FC99]. For this reason and to measure the improvement of the EA management process many different maturity models were developed and published in the past.
The motivation of maturity models is to allow the measurement of the current development status of an organization concerning a certain capability, e.g. EA management or software development [Me09b]. Additionally, they aim at helping enterprises to define steps to rise the value of their IT respectively to improve their capabilities [GRW06]. Thus, they also secure the improvement process by projects and allow a benchmarking between different organizations. At least the maturity models is helping in estimating the costs and efforts of an improved capability.
Today, a number of models exist, which were developed by public departments (cf. [De07, Go03, Of08]). Also many single organizations or enterprises have their own and self-developed plans for the development of their EA management. Thus, there is the assumption that these models have different foundations for evaluating the EA management process. Therefore, two models with different foundations can result in different maturities of the same EA management process.

1.2. Objectives and structure of the bachelor thesis

The main objectives of this thesis is the analysis of existing maturity models, the development of a classification approach and to applying one of the models at an industrial partner in the financial service sector. At first important terms as *enterprise architecture*, *enterprise architecture management*, *maturity*, and *maturity model* are defined. Based on these definitions a review on existing EA management maturity models is given in Section 2.

The result of the review is a selection of models, which are used for the analysis and classification. In Section 3 the analysis and classification approach is developed, helping to examine and compare these models in a standardized, formalized, and detailed way. The analysis and classification framework is developed on the foundation of existing classification approaches. In Section 4, this classification will be validated with the location of the remaining models. In Section 5, one maturity model is applied to an industrial partner, an international financial service provider. Therefore, a documentation of the EA management process is reviewed. Furthermore, a view on the current EA management process is given with the help of an interview partner from the industrial partner. Based on this data the EA management approach of the financial service provider is evaluated by applying the EA management maturity model. This maturity model is selected . The thesis is finished with a recapitulation of all results and a prospect on further areas of research.

1.3. Terms and definition

To define the scope of this thesis it is necessary to have a clear and common understanding of the terms EA management and maturity models. The selected definitions presented below provide the general understanding used in this thesis. They are also used to build the foundation for the analysis approach, particular the process, the items, and the dimensions of EA management maturity models are of interest.

1.3.1. Defining EA management

The use of the terms EA and EA management is inconsistent and heterogeneous. EA is sometimes used synonymical with EA management in literature and in the reviewed maturity models. For example the model by the *Institute for Enterprise Architecture Developments* (IFEAD) is called *extended enterprise architecture maturity model* (E2AMM) but it assesses the maturity of EA management, i.e. by assessing the responsibilities of management in the development of the EA [Sc06]. Therefore, the two terms EA and EA management have to be defined and differentiated. The distinction between the two terms is that EA defines the architecture of an enterprise and EA management the process of managing this architecture. Thus, "every system has an architecture[...]" [BCK05] whether it is documented, planned, or controlled or completely unmanaged. So EA is the IT and business process architecture of an enterprise and their integration. Nevertheless, there is not always a defined process of EA management. This means that no defined processes of managing, developing, and aligning IT to business is present. The reviewed maturity models assesses EA management according to the definition below although some of them call it EA. The term EA is based on the term architecture and therefore, first of all the term *architecture* has to be defined .

> **Architecture** is "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." [In07].

A straightforward definition of the term EA can be found in *Enterprise Architecture As Strategy* by Ross, Weil, and Robertson.

> **EA** is "the organizing logic for core business processes and IT infrastructure reflecting the standardization and integration of a company's operation model" [RWR06].

A broad and detailed definition for EA management is given in the following.

> **EA management** is a continuous and self maintaining management function seeking to improve the alignment of business and IT and to guide the managed evolution of an (virtual) enterprise. Based on a holistic perspective on the enterprise furnished with information from other enterprise-level management functions it provides input to, exerts control over, and defines guidelines for these enterprise-level management functions. The EA management function consists of the activities envision EA, document EA, analyze EA, plan EA, and enforce EA. [BMS09]

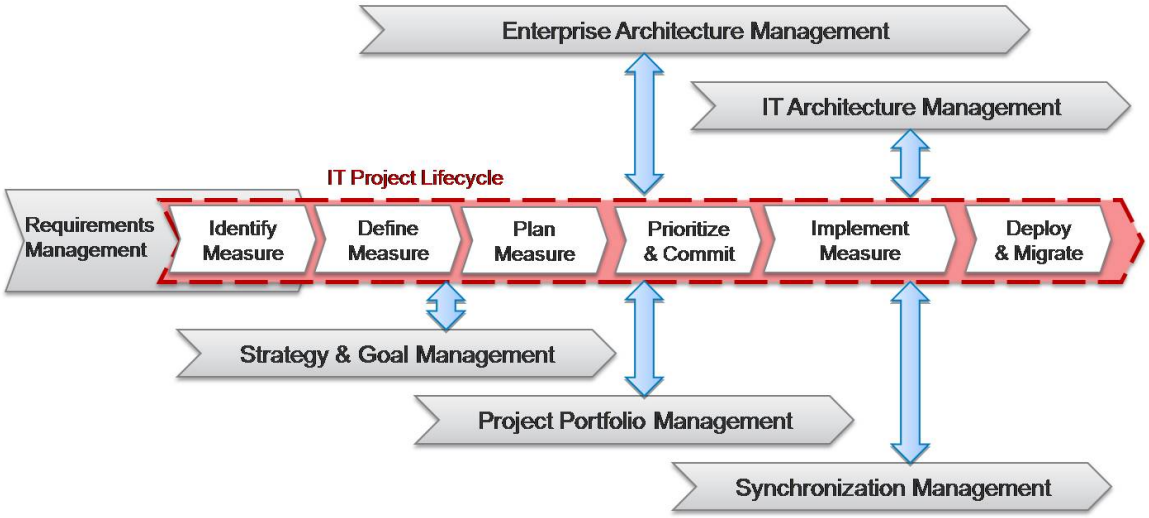

Figure 1.: EA management as glue [BMS09]

This definition of EA management covers the relationship of EA management with other enterprise-level management processes, which are exemplary shown in Figure 1. The definition also includes the activities of EA management [BMS09]:

- *Envision EA*: This activity is concerned with the creation and maintenance of the target EA based on the business and IT strategies. The target EA defines the future business architecture, the future application portfolio, and architecture principles, which are designed in respect of flexibility anticipating emerging changes.
- *Document EA*: This activity is concerned with the creation and maintenance of the documentation of the current EA, including all levels of architecture, e.g. infrastructure, organization, and projects with an impact on the EA. This activity is influenced

by the concerns that drive EA management. The created documentations have to be appropriate to the satisfaction of the concerns[1].

- *Analyze EA*: This activity is about the derivation of architecture plans that are realized by corresponding projects. These architecture plans are derived from the target EA, current EA, and emerging demands from all over the enterprise.
- *Plan EA*: This activity is concerned with making different EA development scenarios comparable in order to prepare a subsequent decision on the EA to realize. Different EA scenarios have different impacts on the properties of an EA and these are of interest for the enterprise, e.g. the impact of an scenario on the flexibility, the costs, and the stability of the EA.
- *Enforce EA*: This activity is concerned with communicating and publishing architecture plans to the enterprise-level management processes. Thus, the activity *enforce EA* effects the decisions in the notified enterprise-level management processes.

The above presented process activities and EA deliverables, which are defined by the activities, can be used for the foundation of the analysis approach (cf. Section 3.2).

1.3.2. Defining maturity model

For the analysis and classification of maturity models a definition of maturity and maturity model is necessary. The term *maturity* refers to the term maturity of a process. This definition of process maturity is derived from the definition of the *Software Process Maturity* published with the guideline of the *capability maturity model* (CMM).

> **Process maturity** "is the extent to which a specific process is explicitly defined, managed, measured, controlled, and effective. Maturity implies a potential for growth in capability and indicates both the richness of an organization's [...] process and the consistency with which it is applied in projects throughout the organization [...]." [Pa95]

That means, that every specific process under consideration always has a defined scope and the growth in capability is measured related to this scope.
Beside process maturity other manners of maturity can be identified. In the following the dimensions of object maturity and people capability are defined.

> **Object maturity** is the extent to which a "specific object like a software product, a report or similar reaches a predefined level of sophistication" [GRW06]

> **People capability** describes "to which extend the workforce is able to enable knowledge creation and enhance proficiency" [No94]

[1] A concern is an subject of interest or importance to a enterprise, e.g. dependencies in the IT infrastructure

EA management is in practice a very complex process, consisting of many activities, which have their own defined scope. Further, it involves many different objects and people. Maturity models can be used for an assessment because, they are structuring and defining an abstract prospect on these processes, objects, and people.

> **A maturity model** can be described as "a structured collection of elements that describe certain aspects of maturity in an organization, and aids in the definition and understanding of an organization's processes." [Pa95]

That means, the aim of a maturity model is to support a comparison with other enterprises and identify optimization potentials in an organization's process. Maturity models for example the *capability maturity model integration* (CMMI) are also used for the definition of service-level agreements (SLA). On the foundation of the assessment and the resulting maturity level of a maturity model SLAs are defined. With regard to the distinguished

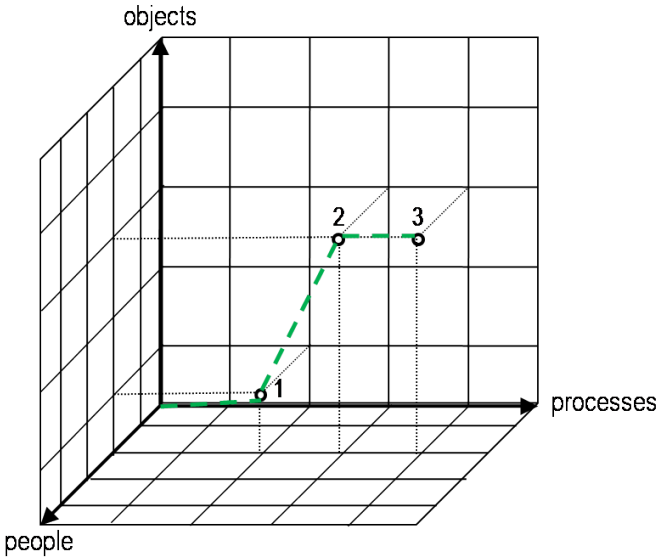

Figure 2.: Different ways of progressing the level of maturity [Me09a]

dimensions of maturity a maturity model can define the progress of an organization's enhancement in different ways. Figure 2 shows examples for this progress. In the first case (1) the level of maturity is increased for all the three dimensions, e.g. learn the workforce to create EA transition plans in a standardized manner by using standardized techniques. In the second case (2) the level of maturity is enhanced only for two factors, i.e. using a repository to manage EA documents. As last example (3) the maturity is enhanced in only one direction, i.e. the using a process model for project management. Understanding the differences of these maturity definitions is especially important when analyzing the models.

Summing up an EA management maturity model is a model, used to identify potentials for improvement in the management and alignment of business and IT. The dimensions

are the continuous process composed of the different activities, the workforce's abilities to govern IT and business , and the used EA deliverables.

2. State-of-the-art of maturity models in EA management

Various EA management maturity models, whose origins date back to 2002 exist today. In the following an overview about the state-of-the-art is given including a first classification of EA management maturity models according to their origin. Thereby, a distinction is made in practitioner-based, academic, and public models.
The public models are mainly developed by public departments and non-profit organizations. In particular these models are supposed to result from specific characteristics and requirements of the public departments. Thus, they have to be reviewed regarding to their applicability in practice.
Academic models were developed at university environments, like the CMM which was published by the Carnegie Mellon Software Engineering Institute in 1991 [Pa95]. Therefore, it is supposed that they are derived from literature and theoretical foundations. Their applicability in practical environment have to be reviewed too.
The practitioner-based models were developed in a practitioner-based environment. This includes developments for internal business issues and special requirements of single enterprises and organizations. They have to be reviewed concerning their applicability in other enterprises. Moreover, the history of maturity models for EA management is briefly sketched and examples for the aforementioned three types are introduced (cf. Section 2.2).

2.1. Development of maturity models in EA management

The majority of the presented maturity models were developed by U.S. agencies e.g. the *Governance Accountability Office* (GAO), the *National Association of State Chief Information Officers* (NASCIO), or the *Department of Commerce* (DoC). The development was triggered by the *Clinger-Cohen Act* (CCA), formerly the *IT management reform act* (ITMRA), a U.S. federal law approved in 1996. Thus, *Federal Agency Chief Information Officers* (CIO) were assigned with the responsibility to develop and maintain integrated systems architectures [Ch01]. In addition, the *Office of Management and Budget* (OMB) has issued guidance that requires agency information systems to be consistent with federal IT architectures [Ch01]. Thus, the agencies were forced to direct and control their EA management program with regard to the federal IT architecture to achieve consistency. Thereon, the *CIO Council* published the *Federal Enterprise Architecture Framework* (FEAF) in 1999 to promote shared development for common governmental processes and exchange of information among U.S. agencies [Ch99].
Another driver in the development of maturity models was the *Capability Maturity Model* (CMM), and later the *CMM Integration* (CMMI), developed by the *Carnegie Mellon Software Engineering Institute* (SEI). In the past, many disciplines developed capability maturity

models to support process improvement, e.g. the assessment of the software development process of most IT organizations is based on CMMI. An emerging best practice indicates that EA management should be similarly managed [De07]. Thus, CMMI influences the majority of maturity models, and especially the way how maturation is represented.
An overview about the state-of-the-art of EA management maturity models, the relations between the models, as well as the development of the models is given in Figure 3.
The three main stations CCA, FEAF, and CMMI in development of EA management maturity models are presented below.

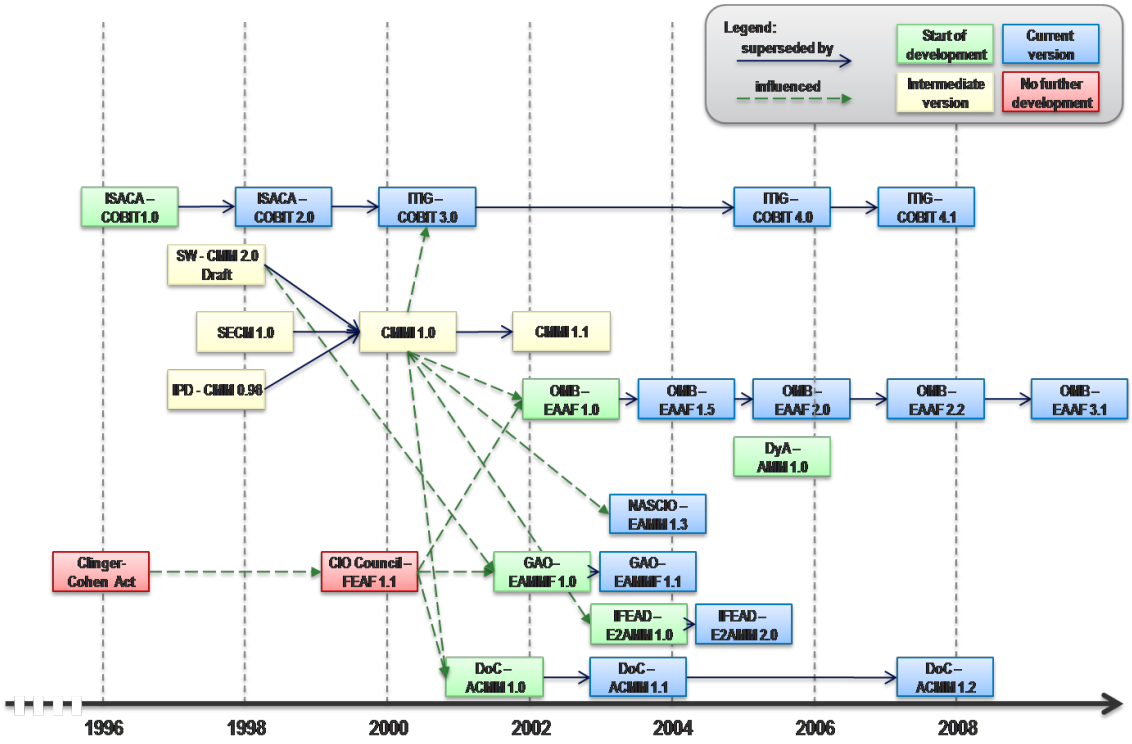

Figure 3.: Relations of EA management maturity models

2.1.1. Clinger-Cohen Act and Federal Enterprise Architecture Framework

CCA specifies that the government and it's agencies should efficiently and profitably operate it's IT as an enterprise. As a part of the CCA, also the ITMRA was adopted because the U.S. departments did not operate efficiently with hardware and software systems, purchased and installed without an overall plan. As result, CCA suggests an integrated framework for IT transitions aimed at efficiently performing the mission of the department and its services [Ho96]. This integrated framework was published with the FEAF.
The FEAF is "a road map for the Federal Government in achieving a better alignment of technology solutions with business mission needs" [Ch99]. This means that FEAF helps to develop the alignment of IT to the needs of agency and it's customers. Therefore, FEAF established components for EA planning – e.g. architecture drivers etc. – and models – e.g. business models, data models etc. – describing the overall organization of architecture

components for developing and maintaining the federated EA. This segmented architecture approach allows individual development of critical parts of an EA, always with regard to an overall EA integration. Thus, the architecture framework is rather a reference point for efficient and effective coordination of EA and investments in the governmental entities in respect to the CCA [Ch99]. Aside, a set of capital planning methods were set up just as they are in private industry. They imply that all acquisition, planning, and management of technology must be treated as a capital investment [Ho96].

2.1.2. Software Engineering Institute – Capability Maturity Model Integration

CMM is a model for assessing the capability of processes. It was originally developed as a tool for objectively assessing the ability of government contractors and their processes to perform a software project [Fu06]. Although, it's origin is in software development, it has also been applied to improve other organizational processes. The model was inter alia adopted to the areas of IT services [Ni05], business processes [Ob07], and human capital management [CHM01]. The CMM was extensively used in government projects [Fu06] and it was also adopted in private industry, especially in software and application development enterprises [Fu06]. In particular, organizations offering offshore outsourcing services around the world use the CMMI, as an instrument for maturing purpose and the definition of SLAs. The CMM has been displaced by the CMMI in 2002. The objective of CMMI is to thwart the uncontrolled growth of CMM models in the different disciplines and provide a modular, simplified, and standardized model. During the evolution of CMM to CMMI two basic representations of maturation were identified the staged and the continuous maturation [Fu06].
The staged representation was already used in the CMM. A maturity level in the staged approach is a defined and enclosed step in improvement, consisting of a number of *key process areas* (KPA) specific to that stage. KPAs are the basic structuring elements, which all models have in common [So02]. A KPA describes related practices of a certain process issue e.g. project management or IT security.
The staged approach of CMMI defines five maturity levels for an organizational processes. Every maturity level is the foundation for the next level and can not be omitted. The stages according to [So02] are:

- **Maturity level 1: Initial** (chaotic, ad hoc, heroic) – is the starting point for an evaluation of a new process. The process is uncontrolled and reactive. Reactive describes an action only triggered by external events, errors, and defects. Although, an organization at level one can be able to create functional products, but the success of the creation and efficiency in creating this product depends largely on the employees.
- **Maturity level 2: Repeatable** (project management, process discipline) – describe a repeatedly used process. The process is also reactive.
- **Maturity level 3: Defined** (institutionalized) – the process is defined and confirmed as a standard process. It is proactive, that means an organization causes the development of events through sophisticated planning and target-oriented acting.
- **Maturity level 4: Managed** (quantified) – process management and measurement takes place.

- **Maturity level 5: Optimizing** (process improvement) – process management includes deliberate process optimization and improvement.

The continuous representation is used in *Integrated Product Development – CMM* [Mc98] and in *Systems Engineering – Capability Model* [Ba95]. It "offers a flexible approach to process improvement" [CKS03]. The organization has the latitude in selecting the KPA that should be improved. Thus, the organizations are able to improve single KPAs e.g. an organization focuses on improvement of a specific process-related trouble spot, respectively a less developed capability [CKS03]. But, the latitude in improvement is restricted to the dependencies between the KPAs. The continuous approach uses in contrast to the staged approach *Capability Levels* for describing the state of improvement.
The difference between maturity and capability levels is that an capability level only classify the ability of an organization within a certain KPA, e.g. IT security or maintenance of EA deliverables, whereas a maturity level classify the overall ability of an enterprise level process, e.g. EA management or software development. Thus, a maturity level is derived from the capability levels of the KPAs. The six levels according to [So02] are:

- **Capability Level 0: Incomplete** – An incomplete process not performed or only partially performed, viz. one or more of the goals of the KPA is not fulfilled.

- **Capability Level 1: Performed** – A performed process has satisfied the specific goals of the KPA. It supports and enables the work needed to produce identified output – e.g. deliverables – using identified inputs – e.g. descriptions.

- **Capability Level 2: Managed** – A managed process is planned and executed in accordance with policy, resources, and relevant stakeholders. The performance of the process is compared to the plan and corrective actions are taken when the actual results and performance, e.g. cost, quality objectives, and schedule, deviate significantly from the plan.

- **Capability Level 3: Defined** – A defined process is tailored from the organization's set of standard processes according to the organization's specific guidelines, artifacts, measures, and other process-improvement information to the organizational process assets. As distinguished from a managed process two projects within the same organization are similarly directed and controlled.

- **Capability Level 4: Quantitatively managed** – A quantitatively managed process is controlled via appropriate statistical and quantitative techniques to manage the current and predict the future performance of a process. The quality and process performance are understood in statistical terms and are managed throughout the life of the process.

- **Capability Level 5: Optimizing** – An optimizing process is continuously improved by changing and adapting the process to meet the current and projected business objectives. Therefore, both incremental and innovative technological improvements are used. These improvements are selected based on their expected influence on the organization's process-improvement objectives compared to the cost.

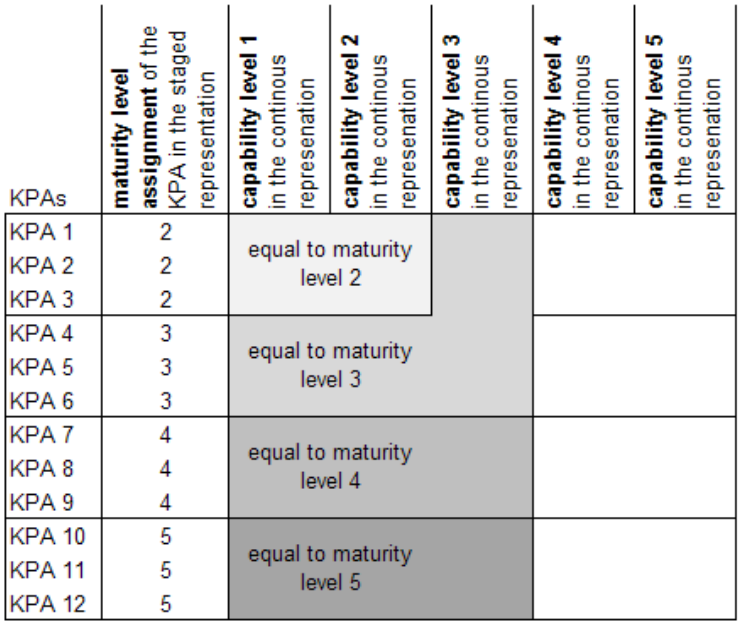

Figure 4.: Equivalent staging of continuous and staged approach [So02]

CMMI determines general rules for an equivalent staging of the continuous and staged representation, showing the relation between the staged and the continuous representation. An example for an equivalent staging is shown in Figure 4. The shaded areas in Figure 4 do not extend into the capability levels 4 and 5, because choices will be dependent upon the selections made by the organization in its implementation of the maturity level 4 and 5 process areas. The rules for an equivalent staging are:

- To achieve maturity level 2, all process areas assigned to maturity level 2 must achieve capability level 2 or above.
- To achieve maturity level 3, all process areas assigned to maturity levels 2 and 3 must achieve capability level 3 or above.
- To achieve maturity level 4, all process areas assigned to maturity levels 2, 3, and 4 must achieve capability level 3 or above.
- To achieve maturity level 5, all process areas must achieve capability level 3 or above.

As aforementioned a KPA is a cluster of related practices in an process issue. The CMMI defines that a KPA has a number of *specific goals* and *generic goals*. According to [So02]:

- A *specific goal* describe what have to be implemented to satisfy the KPA. To achieve satisfaction of this specific goal the model defines a number of activities expected to result in achievement of this specific goal. These activities are named as specific practices and each is associated with a capability level.
- A *generic goal* describes the institutionalization that the organization must achieve at that capability level. The achievement of a generic goal in a KPA signifies improved

control in planning and implementing the processes associated with that KPA. The CMMI has five generic goals and each of these goals is a part of every KPA. The CMMI also defines a number of generic practices for institutionalization to ensure that the processes associated with the KPA will be effective, repeatable, and lasting. In the continuous representation, each generic practice maps to one generic goal.

If the practices defined by the maturity model are performed collectively, they satisfy the positioned goals seen as important for the improvement in that KPA(cf. [So02]).

2.2. Overview about EA management maturity models

An overview about backgrounds, the accountable organizations, and the reasons why the maturity models were developed as well as the basic idea how the models assesses maturity of EA management is given below. Onto these information it is decided which models will be used for a detailed analysis. The section finishes with a description of the EA management maturity models developed by private enterprises.

2.2.1. Public EA management maturity models

The public EA management maturity models are developed by governmental organizations. The following models were all developed by U.S. agencies. These agencies which had developed the EA management maturity models were head organizations. This means that they are the head of a number of smaller agencies, e.g. the DoC, or that they are working in cooperation with a number of other agencies. This implies that they were able to take the situation of the different agencies into account during the development and enforce the application of the maturity models.

U.S. Governance Accountability Office – EA management maturity framework

The U.S. GAO[1] is an independent, nonpartisan agency that works for the U.S. Congress. It investigates how the federal government spends taxes and gives advice for more efficient usage. In this scope the GAO developed the EA management maturity framework (EAMMF). "It is a benchmarking tool for planning and assessing enterprise architecture efforts" [Go03]. The foundation for this model refers to the *CIO Council's* practical guide to Federal Enterprise Architecture [Ch01, Go03]. The EAMMF was determined for common use in improving the EA management at federal agencies [Go03]. The first version of EAMMF was published in February 2002 and updated in April 2003 to version 1.1 (cf. Figure 3).
Figure 5 shows the EAMMF structure and the maturation levels. EAMMF defines the typical five levels of a stage-oriented maturity model. Each level has a number of KPAs specific to that level, so called core elements, describing a practice or a condition that is regarded to be needed for effective EA management. Overall there are 31 core elements defined that should be fulfilled. The core elements, e.g. "Chief architect exists" or "Program office

[1] www.gao.gov

	Stage 1: Creating EA awareness	Stage 2: Building the EA management foundation	Stage 3: Developing EA products	Stage 4: Completing EA products	Stage 5: Leveraging the EA to manage change
Attribute 1: Demonstrates commitment		Adequate resources exist. Committee or group representing the enterprise is responsible for directing, overseeing, or approving EA.	Written and approved organization policy exists for EA development.	Written and approved organization policy exists for EA maintenance.	Written and approved organization policy exists for IT investment compliance with EA.
Attribute 2: Provides capability to meet commitment		Program office responsible for EA development and maintenance exists. Chief architect exists. EA is being developed using a framework, methodology, and automated tool.	EA products are under configuration management.	EA products and management processes undergo independent verification and validation.	Process exists to formally manage EA change. EA is integral component of IT investment management process.
Attribute 3: Demonstrates satisfaction of commitment		EA plans call for describing both the "as-is" and the "to-be" environments of the enterprise, as well as a sequencing plan for transitioning from the "as-is" to the "to-be." EA plans call for describing both the "as-is" and the "to-be" environments in terms of business, performance, information/data, application/service, and technology. EA plans call for business, performance, information/data, application/service, and technology descriptions to address security.	EA products describe or will describe both the "as-is" and the "to-be" environments of the enterprise, as well as a sequencing plan for transitioning from the "as-is" to the "to-be." Both the "as-is" and the "to-be" environments are described or will be described in terms of business, performance, information/data, application/service, and technology. Business, performance, information/data, application/service, and technology descriptions address or will address security.	EA products describe both the "as-is" and the "to-be" environments of the enterprise, as well as a sequencing plan for transitioning from the "as-is" to the "to-be." Both the "as-is" and the "to-be" environments are described in terms of business, performance, information/data, application/service, and technology. Business, performance, information/data, application/service, and technology descriptions address security. Organization CIO has approved current version of EA. Committee or group representing the enterprise or the investment review board has approved current version of EA.	EA products are periodically updated. IT investments comply with EA. Organization head has approved current version of EA.
Attribute 4: Verifies satisfaction of commitment		EA plans call for developing metrics for measuring EA progress, quality, compliance, and return on investment.	Progress against EA plans is measured and reported.	Quality of EA products is measured and reported.	Return on EA investment is measured and reported. Compliance with EA is measured and reported.

maturation

Figure 5.: U.S. GAO - Enterprise Architecture Management Maturity Framework [Go03]

responsible for EA development and maintenance exists", are associated to one of four types of management attributes so called *critcal success attributes*, e.g. "Demonstrates commitment" or "Provides capability to meet commitment" [Go03].

National Association of State Chief Information officers – EA Maturity Model

National Association of State Chief Information Officers[2] (NASCIO) represents the CIOs from the 50 U.S. states, six U.S. territories and the District of Columbia [Na03]. So the NASCIO is a federal organization and it's goal is to assist state and local governments in

[2]http://www.nascio.org/

their IT programs. Concerning the mission to support the federal and local IT programs the EA Maturity Model (EAMM) was initially developed as a benchmarking tool for the effectiveness of an architecture program [Na03]. The NASCIOs EAMM (cf. Figure 6) is

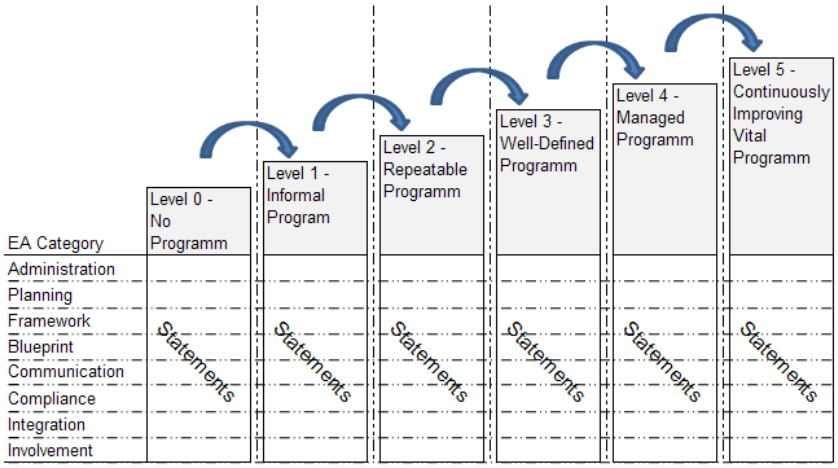

Figure 6.: NASCIO – Enterprise Architecture Maturity Model scheme

founded on the structure of the CMM [Na03]. Thus, it has six *capability level* and each level contains requirements that are indicative of an EA Program of a certain stage. The model defines eight KPAs. A level of maturity can be reached by fulfilling all statements of a KPA at a certain level and all previous statements. Thus, it can be classified as a model with a continuous approach (cf. Section 2.1.2).

U.S. Office of Management and Budget – EA Assessment Framework

The U.S. OMB[3] is a Cabinet-level office, and it is the largest office within the *Executive Office of the President* (EOP). It is an important channel by which the White House oversees the activities of federal agencies. Therefore, OMB is tasked with giving expert advice to senior White House officials on a range of topics relating to federal policy, management, including EA management, budgetary issues and some more. The *EA Assessment Framework* (EAAF) was the result of budgetary and federal policy issues of the EOP, because the EOP with "approximately $70 billion in annual spending had to manage IT investments effectively" [Of08]. The EAAF is also founded on the CMMI and has six stages of maturity. The KPAs are separated into the three capability areas *Completition*, *Use*, and *Results* (cf. Figure 7). Each capability area has clearly defined outcomes.

U.S. Department of Commerce – Enterprise Architecture Capability Maturity Model

DoC[4] is a part of the U.S. government and it is accountable for the interests of the united states economy. DoC and its 16 operation units made heavy investments in an enterprise-wide EA in 200X [De07]. Therefore, the DoC needs to ensure that it continues to build

[3]http://www.whitehouse.gov/omb/
[4]http://www.commerce.gov/

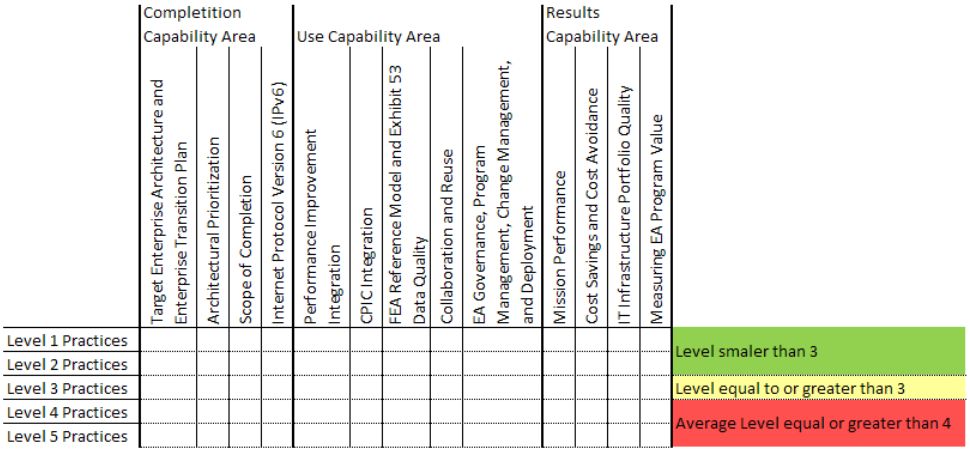

Figure 7.: OMB – EA Assessment Framework scheme

on previous efforts and fully realize the benefits of the developed EA. To reach this goal the *Enterprise Architecture Capability Maturity Model* (*ACMM*) was developed aiming at an evaluation of the current EA process and to set up a path where EA management should go in the 16 operation units of the DoC [De07]. The initial draft (version 1.0) of the ACMM was released in 2001 and evolved to version 1.2 in December 2007. Like other institutions the maturity model of the DoC is based on the continuous representation of the *CMMI*. Thus, it defines six levels of maturity and nine KPAs (cf. Figure 8). Each KPA has one defined so called *architecture characteristic*. This is the requirement for reaching a level in a certain *KPA*.

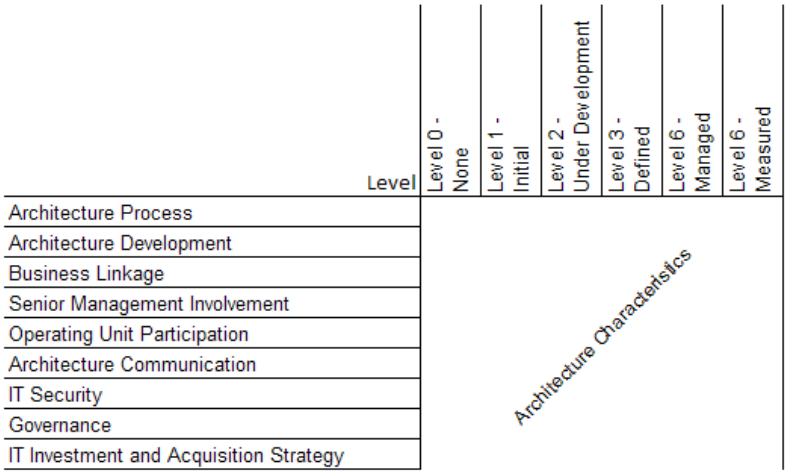

Figure 8.: DoC – EA Assessment Capability Maturity Model

2.2.2. Practitioner-based EA management maturity models

The maturity models of this paragraph are developed by organizations with an practitioner-based background, like enterprises, consultancies, or other organizations. Thus, they are also developed for the appliance within practice. In contrast to the agencies that have to meet many requirements of the legislative concerning organizational structures, or reports the enterprises are developing largely free and in an dynamic environment. Therefore, the models of the consultancies and organizations, which are designed for different companies have to make different aspects comparable.

Dynamic Architecture – Architecture Maturity Matrix

Dynamic Architecture (DyA) is a program by *Sogeti*[5], which is an affiliated company of *Capgemini*[6]. Sogeti lies its focus on software tests and quality management of services. The Architecture Maturity Matrix (AMM) was developed by Marlies von Steenbergen, who has been working since more than 10 years in practice. The idea of AMM is that "the right

Scale / Area	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Development of architecture		A			B			C						
Use of architecture			A			B				C				
Alignment with business		A				B				C				
Alignment with the development process			A				B		C					
Alignment with operations					A			B			C			
Relation to the as-is state					A				B					
Roles and responsibilities				A		B					C			
Coordination of developments							A			B				
Monitoring				A		B		C		D				
Quality Management								A		B			C	
Maintenance of the architectural process							A		B		C			
Maintenance of architectural deliverables					A			B					C	
Commitment and motivation		A					B		C					
Architecture roles and training				A		B			C			D		
Use of an architectural method				A						B				C
Consultation			A		B				C					
Architectural tools							A				B			C
Budgeting and planning				A							B		C	

Figure 9.: DyA – Architecture Maturity Matrix Scheme

aspect [should] be given the right amount of attention at the right time" [St05]. That means that it is necessary in different situations to focus on different aspects in the development of EA management in an organization. In contrast to the other maturity models presented before the AMM was neither founded on the staged-oriented approach nor the continuous approach of the CMMI. The AMM belongs to the class of *focus oriented models* [St05]. The approach of focus oriented models is in-depth described in Section 3.1.1. Furthermore, the AMM should allow a more fine grained approach [SBB07]. Thus, makes it more suitable to the purpose of improving the EA management process [SBB07]. AMM defines 18 KPAs (cf. Figure 9) and each has its own growth path and number of maturity stages, which are

[5]http://www.sogeti.com/
[6]http://www.capgemini.com/

labeled with capital letters from A to a maximum of D. Thus, it should be more precise and provides more detailed guidance [St05]. To reach a level of maturity in a certain area the organization have to fulfill all items from left to right until you reach one of the letters. As an example you have to fulfill two items for reaching the maturity stage *A* in the area *Development architecture* (cf. Figure 9). In contrast to the other models, the AMM items are simple yes/no questions and refer to the requirements of an stage. Thus, the fulfillment of an maturity stage can be easily determined through answering of all questions of an certain maturity stage with yes. So, the AMM has an questionnaire to assess the maturity of an organization.

Institute for Enterprise Architecture Developments – Extended Enterprise Architecture Maturity Model

The *Institute for Enterprise Architecture Developments*[7] (IFEAD) is a research and information exchange organization working in relationship with enterprises and public departments [Sc06]. It is classified as a practitioner-based model because, the incorporator and chairman J. Schekkerman has worked as an EA management practitioner for several years. Like other continuous CMMI models the *E2AMM* defines five levels of maturity (cf. Figure 10). Eight KPAs were identified and the level of maturity can be typically assessed by the descriptions related to each KPA and each maturity stage. The descriptions are increasing in extend with an increase of the maturity level within a KPA [Sc06].

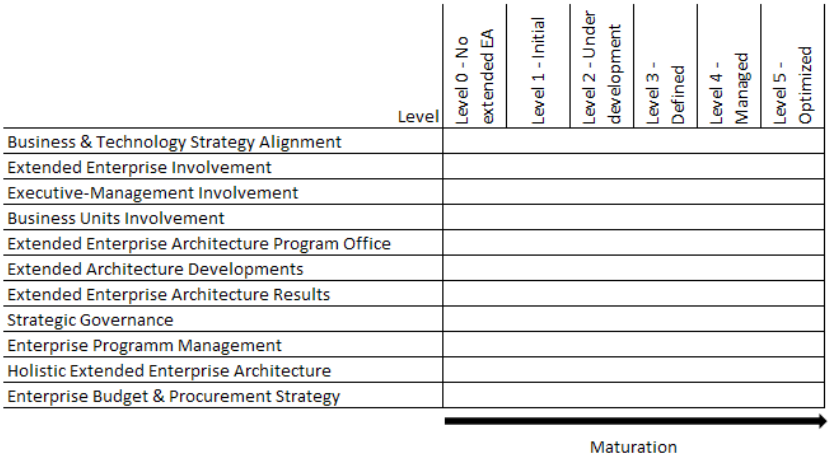

Figure 10.: IFEAD – Extended Enterprise Architecture Maturity Model Scheme

IT Governance Institute – Control Objectives for Information and related Technology maturity model

The *IT Governance Institute* (ITGI) was founded by the professional organization of IT auditors, the *Information Systems Audit and Control Association* (ISACA) in 1998. The ITGI has the aim to advance international thinking and standards in directing and controlling an

[7] http://www.enterprise-architecture.info/

enterprise's IT [IT07]. The *Control Objectives for Information and related Technology* (*COBIT*) framework was originally developed by the ISACA, but the responsibilities for the development and support of the framework was transfered to the ITGI in 1998. Thus, the *COBIT* framework is grouped as a practitioner-based model.
The *COBIT* framework provides a link to business requirements and it organize the IT activities into a generally accepted process model. Further, it identifies the major IT resources to be leveraged and it defines the management control objectives to be considered [IT07]. Therefore, *COBIT* identifies 34 processes, grouped in four *responsibility areas* of *Plan and Organize*, *Acquire and Implement*, *Deliver and Support*, and *Monitor and Evaluate*. These phases are following the management cycle. The *COBIT* maturity model is an "IT governance tool used to measure how well a typical management processes are with respect to internal controls" [Pe03]. Although, it is an IT governance tool it can also be used for assessing the EA management of an organization. It allows to assess the current *as-is* maturity levels and define *to-be* (future) maturity levels as well as gaps to fill. The *COBIT* maturity bases also on the structure of the continuous approach of CMMI and defines the typical six *capability stages* for each KPA (cf. Figure 11). Typical KPAs of the *COBIT* framework are *Define a Strategic IT Plan* ,*Define the Information Architecture*, *Manage IT Human Resources*, and *Acquire and Maintain Application Software*. Obviously, the framework also support a more general view on the enterprise IT and not only on EA management.

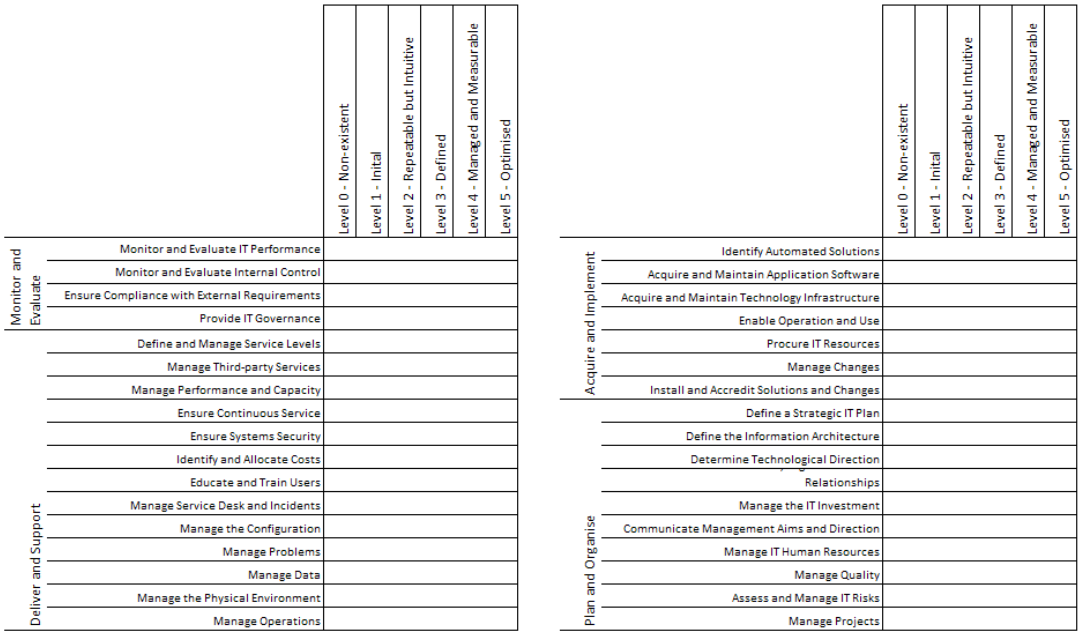

Figure 11.: ITGI – Control Objectives for Information and related Technology

Deutsche Post AG – SOA-Management Maturity Model

The Deutsche Post AG has developed an own maturity model approach. This model separately assesses the improvement of the IT architecture and the organizational architecture of the enterprise's divisions. Therefore, it defines six levels of maturity with special re-

quirements for improving the architecture and the organizational architecture. For each of the maturity levels artifacts are defined, which should be available if the respective level is reached. Another specification is that the levels of the IT and the organizational architecture should not differ more than one level. [GM08]

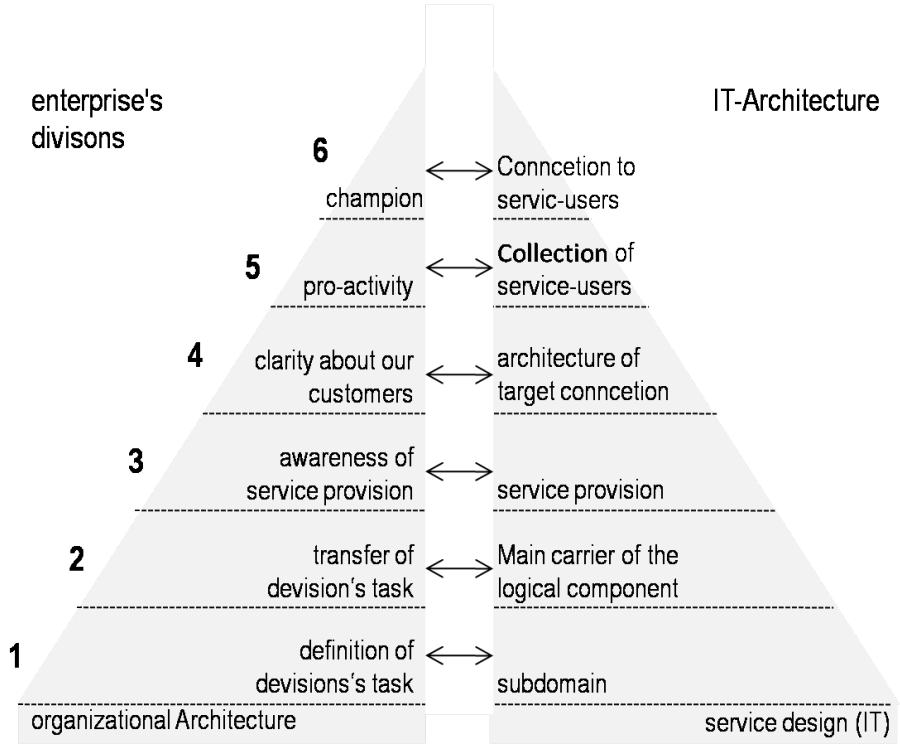

Figure 12.: Deutsche Post AG – SOA-Management Maturity-Model

alfabet AG – SACA

alfabet AG is a German consulting enterprise, which has developed an assessment for EA management maturity focusing on the tool usage in the context of EA management. This maturity assessment covers three perspectives: *IT processes*, *IT architecture*, and*IT organization* and it defines five levels of maturity. The model's maturity levels are *Initial*, *See*, *Analyze*, *Control*, and *Align* and they refer to the use of tools and methods within the development of EA management.
The initial maturity level describes the usage of manual methods and basic tools in EA management, like Microsoft Office.
The second maturity level *See* is described through the use of repositories to document each discipline, but these disciplines are not integrated.
The maturity level *Analyze* is described through the usage of dedicated tools for each discipline to perform analysis and planning, e.g. Mercury for project portfolio management.
The maturity level control is desibled through the appliance of overarching process frameworks to support the IT lifecycle processes and leverage the integrated information throughout the processes.

The maturity level Align is described through the establishment of pro-active mechanisms to steer the IT lifecycle processes and monitor their performance.

The KPAs are founded on the phases of the IT lifecycle management process, like *Business Demand Management* or *Business Object management* [Pr08].

2.3. Selection of maturity models

The characteristics of EA management maturity models identified in Section 2.2 are summarized in Table 1. The characteristics *origin*, *representation of maturity* ,*number of KPAs*, and the *age of the last version* are used for the selection of maturity models to develop the classification and analysis framework. Based on the relations (cf. Figure 3) and characteristics (cf. Table 1) of the maturity models it is also meaningful to select the maturity models with different foundation. The selected maturity models are denoted in Table 1 and the motivation for the selection is presented in the following.

The EAMMF and the AMM are selected due to their representation of maturity. The EAMMF is the only model with an staged maturity representation [Go03] and the AMM is the only one, which defines a focus-oriented approach [St05]. Furthermore, the maturity models should be as up-to-date as possible. In addition the practitioner-based and public maturity models should be incorporated. *COBIT* was excluded from the selection, because it has a broader subject, which is significantly related to IT governance [IT07].

	REPRESENTATION OF MATURITY			ORIGIN			OTHER		
	Staged representation	**Continous representation**	**Focus area representation**	**Public**	**Academic**	**Practitioner-based**	**Number of KPAs**	**Year of the last version**	**Selection**
U.S. GAO – EAMMF	✓			✓			–	2003	✓
NASCIO – EAMM		✓		✓			8	2003	
U.S. OMB – EAAF		✓		✓			13	2009	✓
ITGI – *COBIT*		✓				✓	34	2007	
U.S. DoC – ACMM		✓		✓			9	2008	✓
DyA – AMM			✓			✓	18	2005	✓
IFEAD – E2AMM		✓				✓	11	2005	✓

Table 1.: Selection of EA management maturity models

3. Design of an analysis and classification approach

This section presents the development of an analysis and classification framework. At first, existing classification approaches are introduced and reviewed in respect to reuse and improvement. The aim of the classification and analysis framework is to investigate how the maturity models support the two basic objectives of measurement and development in EA management. Therefore, it is necessary to classify the models in respect to their structural properties and scope. The structural properties define how the model supports the EA management assessment and the scope define which dimensions of the process are measured by the maturity model.

3.1. Review of former classification approaches

There are various classification approaches for specific types of maturity models e.g. maintenance maturity models(cf. [KM02]). These classification approaches for specific maturity models cannot be used for the classification of EA management maturity models, because they refer to characteristics of their application area. Therefore, the development of the classification and analysis approach rely on more universal approaches, as well as existing approaches for the classification of maturity models in EAM. Two of these approaches are presented and examined in the following.

3.1.1. Classification of maturity models according to Steenbergen

The classification approach for architecture maturity models of Steenbergen is shown in Figure 13. It identifies three basic types of architectural maturity models [SBB07]. The basic types differ according to the way how maturity is presented. As a part of the classification the two types from CMMI (cf. Section 2.1.2) – the staged and continuous 5-level approach – are taken up. Additionally, a third type is identified – the *focus area oriented models* [SBB07]. These three types as identified by Steenbergen are described subsequently.

Staged 5-level models correspond to the staged representation in CMMI. It defines five levels of maturity where each level has a number of level-specific KPAs[1]. These KPAs have to be implemented to achieve the respective level. An example for an EA management maturity model, which can be classified as staged 5-level model is the U.S. GAO – EAMMF [Go03].

[1] Steenbergen uses the term *focus areas instead* of *KPAs*. In order to use a consistent terminology it is sticked to the term KPA in the following.

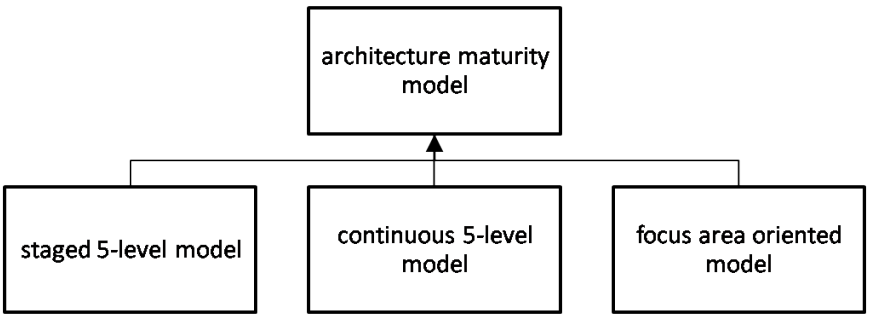

Figure 13.: Classification of architecture maturity models by Steenbergen [SBB07]

Continuous 5-level models correspond to the continuous representation in CMMI. It defines five general maturity levels and a number of KPAs. Unlike the staged 5-level models, KPAs in the continuous 5-level models are not specific to a level. Within each of these KPAs the five overall levels are defined. The majority of the reviewed models from Section 2.2 are based on this concept e.g. the: NASCIO's – EAMM [Na03], DoC's – ACMM [De07], or OMB's – EAAF [Of08].

Focus area oriented models depart from the idea that there are five generic maturity levels, instead each KPA has its own specific number of maturity levels. The overall maturity of an organization is expressed as a combination of the maturity levels of the different focus areas [SBB07]. A model using this approach is the AMM of DyA [St05].

3.1.2. Classification of maturity models according to Mettler

Additional classification criteria for maturity models can be taken from the decision parameters identified in *a design science perspective on maturity models* by Mettler (cf. [Me09a]). Two perspectives are identified in the paper – the *developer's perspective* and the *user's perspective* (see Figure 14). Whereas both perspectives are of interest for the development of an analysis and classification approach, the latter perspective is especially of interest for the case study at the industry partner (see Chapter 5). The decision parameters for the development of a maturity model are shown in the Table 2. During the development of a model several decision parameters concerning the properties of the maturity model are identified. This decision parameters are important for the classification framework.

Closely linked with this development process is the appliance of maturity models [Me09a]. The decision parameters for applying a maturity model in an organization are shown in Table 3. They refer to the phases shown in Figure 14.

The developer's perspective

Developing an artifact in design science is usually initiated by the identification of a need or opportunity [Jä07, Pu02] and followed by the four phases *define scope*, *design model*, *eval-*

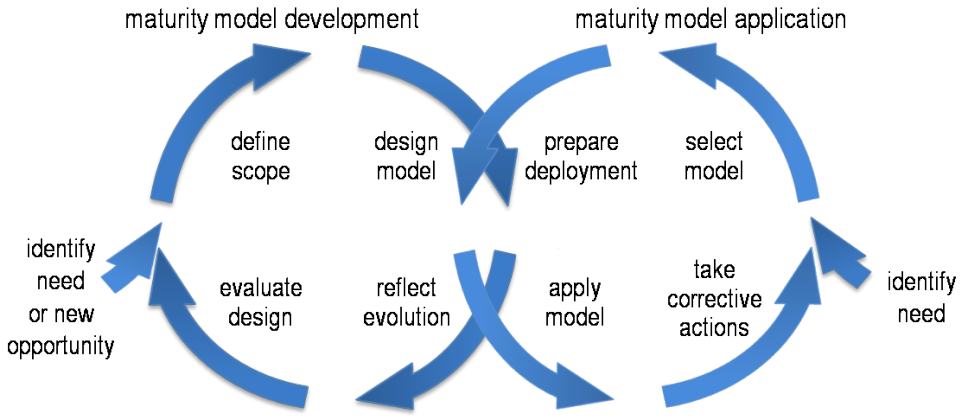

Figure 14.: Phases in applying an maturity model [Me09a]

uate design, and *reflect evolution* (cf. Figure 14). The decisions made in this phases are shown in Table 2 and explained as well as discussed subsequently.

Phase: Define scope In this phase "the developer is faced with the most important design decisions" [Me09a]. The maturity models have already been selected by the subject of EA management maturity. The decisions of this phase according to [Me09a] are:

- **Focus / breadth:** This decision parameter influences all the following decision parameters, by setting the subject under consideration. The designer has the opportunity to choose a general subject – e.g. a learning organization – or a specific subject – e.g. the maturity of quality management at a financial service provider. The focus depends on the objective of the model. It classifies the general aspects of the model and the KPAs. Thus, it also determines the scope of the model and its degree of abstraction, e.g. an organization-specific model, like the U.S. OMB – EAAF [Of08] has tailored KPAs for the organization.

- **Level of analysis / depth:** This decision parameter defines the maturity model's *operating altitude* [Me09a]. The maturity of an process can be assessed on the group level, on the organization level, on the inter-organizational level, or on a more global and societal level. The goal of the model also determines the level of it's application. The availability of information for the assessment entirely depends on the organizational level where the assessment takes place. For example at a high organizational level there is information available about the general context and the dependencies between the processes than on the group level. This obviously requires differentiation of the requirements and questions according to their degree of abstraction. So the degree of abstraction is higher for high-level processes.

- **Novelty:** This decision parameter includes considerations on the novelty of the subject, e.g. if it is a mature or an emerging phenomenon. This decision depends largely on the selected subject of the model and thus, it is not really a design decision but rather objectively given.

PHASE	DECISION PARAMETER	CHARACTERISTIC			
Define scope	Focus/ breadth	General issue		Specific issue	
	Level of analysis/ depth	Group decision making	Organizational considerations	Inter-organizational considerations	Global and societal considerations
	Novelty	Emerging	Pacing	Disruptive	Mature
	Audience	Management-oriented	Technology-oriented		Both
	Dissemination	Open		Exclusive	
Design model	Maturity Definition	Process-focused	Object-focused	People-focused	Combination
	Goal function	One-dimensional		Multi-dimensional	
	Design process	Theory-driven	Practitioner-based		Combination
	Design product	Textual description of form	Textual description of form and functioning		Instantiation (assessment tool)
	Application method	Self-assessment	Third-party assisted		Certified professionals
	Respondents	Management	Staff	Business partners	Combination
Evaluate Design	Subject of evaluation	Design process	Design product		Both
	Time-frame	Ex-ante	Ex-post		Both
	Evaluation method	Naturalistic		Artificial	
Reflect evolution	Subject of change	None	Form	Functioning	Form and functioning
	Frequency	Non-recurring		Continuous	
	Structure of change	External/ open		Internal/ exclusive	

Table 2.: Decision parameters during maturity model development [Me09a]

- **Audience:** This decision parameter tailors the model to the needs of a management-oriented audience, a technology-oriented audience, or a combination of both. This is another goal-related criteria of the model. The audience is also reflected in the perspective of the model. A management-oriented audience is more interested in the maturity of management processes and has not much interest in technology issues, and vice versa.
- **Dissemination:** This decision parameter specifies, if the model is open to the audience or has exclusive access only. On the one hand a maturity model gathers more feedback when it is accessible for public, on the other hand there is a risk of dilution. This risk can be avoided with an exclusive accessibility.

Phase: Design model After the scope of the maturity model is set, the model is built. Some of the decision parameters e.g. the design process and the design product are constrained by the available resources, e.g. business partners and developers [Me09a]. The identified decisions according to [Me09a] are:

- **Maturity definition:** This decision parameter specifies the understanding of maturity. If the model has a process-focused understanding of maturity, it focuses on activities and work practices. If the model is object-focused, the features, e.g. functional and non-functional requirements, are assessed to enhance their mode of operation. If the model focuses on people, the emphasis of the model lies on people's behavior. The various dimensions of process, people, and objects influence each other. The behavior of the people directly influences the execution of the process. The execution of the processes affects the quality of results and these results serve as input for the processes and influence subsequent the execution of the processes again. Process maturity models are cross-focused, because a process is always considered in the context of roles (people) and objects. Therefore, requirements for people and objects can be derived from the processes. In contrast, the requirements at the process can not be derived from requirements at the workforce or objects. The requirements at the workforce or the objects stand for them self and are not linked with processes.
- **Goal function:** This decision parameter is about the progress of maturity. The one-dimensional progress focuses on only one target e.g. efficiency. In contrast, the multi-dimensional progress focuses on multiple and sometimes divergent goals. This criteria defines what is considered by the maturity development within the model. It allows to include the dynamics of an object in its environment in the assessment. Nevertheless, the assessment becomes more complex with an increasing number of goal functions.
- **Design process:** The design process has to be documented to clarify the foundation for the maturity levels and the metrics. Three dimensions were identified – theory-driven, practitioner-based, or a combination. The defined maturity levels, metrics, and questions are influenced by the development perspective. A theory-driven perspective is primarily trying to establish new approaches for the maturity model. In contrast , a practitioner-based perspective aims at higher user acceptance and realistic outcomes. A combination of both should provide the advantages of both approaches.

- **Design product:** This parameter defines the shape of the model. The model can have a textual description of the form or of the form and functioning. Additionally, the maturity model can be instantiated as a software assessment tool. This criteria classifies the descriptions of the KPAs and maturity levels. The design product directly influences the workload for the assessment. If the model is described in detail or implicitly described through a assessment tool, the assessment is more straight forward than a model, where a description is only given on a very abstract level, which gives feeway to the application detail. An assessment tool, for instance, has implemented the rules of the maturity model and supports an early interpretation of results. This also affects the acceptance of the model, e.g. through an improved cost-benefit ratio.
- **Application method:** The application method determines the process of data collection. The collection can be performed by the organization itself, a third party, or a certified professional. Obviously, the selected mode significantly influences the costs of the maturity model application. An self-assessment uses the organizations resources, but the experience gained during the application of the maturity model may produce expertise and therefore cost benefits for future applications. The disadvantage of the self-assessment are reliability problems of the results, which might be caused by subjectivity of the auditors. In contrast, the third-party assessment ensures objectivity and validity of the results. To support acceptance of the external auditors the third-party can be a certified professional.
- **Respondents:** The respondents are the involved people for data collection e.g. management, staff, business partners, or a combination of these groups. Depending on the objective of the model it has to be defined which group of persons can answer the questions defined by the model, i.e. it does not makes sense to ask the manager about system details.

Phase: Evaluate design This phase includes the verification and the validation of the developed maturity model. Thus, it determines that the maturity model "represents the developer's conceptual descriptions and specifications with sufficient accuracy [as well as] accurate representation of the real world" [Me09a]. The decision parameters for this phase are:

- **Subject of evaluation:** This decision parameter defines the subject of evaluation. The design process – the way of construction – or the design product – the model itself – or both can be evaluated.
- **Time-frame:** This decision parameter determines the point in time of the evaluation of the model. The model can be evaluated ex-ante or ex-post. The ex-post evaluation bases on the obtained results after the application of the maturity model. In contrast, the ex-ante evaluation investigates the initial state and compares this with the maturity model. A combination of the ex-ante and the ex-post evaluation is possible.
- **Evaluation method:** This decision parameter is concerned with the method of evaluation. The method can be artificial, e.g. an experiment or naturalistic, e.g. a case study.

An appropriate evaluation is necessary to ensure the applicability of the model in practice, especially in a dynamic and volatile area. Although, this phase can influence the properties of the model, these decision parameters do not build a foundation for the development of the classification framework. Therefore, these criteria are not further considered.

Phase: Reflect evolution This phase reflects the variability of the developed maturity model. Especially in an emerging phase of the model's subject, which is characterized by an rapid growth in the worldwide awareness of this subject, new aspects, modifications, and improvements appear. They have to be incorporated in the model from time to time. Therefore, a defined update process is needed, whose decision parameters are part of this phase. The identified decision parameters according to [Me09a] are:

- **Subject of change:** This decision parameter determines whether any changes are necessary or not. Changes to the maturity model are necessary to ensure the quality of the model, as well as the acceptance by users. The changes can be applied to the form, the function, or both. Therefore, this decision parameter has an impact on the properties of the maturity model.
- **Frequency:** This decision parameter determines the frequency of run through the *reflect evolution* phase. This phase can be recurring or not. The maturity model will stay up to date in case of an recurring *reflect evolution phase*, but this is associated with significant expenditures.
- **Structure of change:** This is decision parameter is concerned with changes. These changes can be introduced by the users (open) or by the developer (exclusive).

The goal of this phase is to improve the maturity model. The results of the evaluation are used for this improvement. This is also necessary for the success of the model in practice, but this phase does not provide criteria for the classification.

The user's perspective

A successful appliance of a maturity model pass through the phases *identify need*, *select model*, *prepare deployment*, *apply model*, and *take corrective actions* (cf. Figure 14) [Me09a]. Two categories of decision criteria can be identified in Table 3, property-dependent and property-independent criteria. The property-dependent decision parameters are directly linked to properties of the maturity model. Thus, property-dependent decision parameters are reused for the analysis and classification of this thesis. In contrast the property-independent decisions are decisions taken by the enterprise, which concern largely not effected by the properties of the maturity model, e.g. the final management decision about the application of the maturity model. Thus, they are not reused in the classification and analysis approach of this thesis.

Phase: Select model The *select model* phase starts with a search for suitable maturity models concerning the identified business needs. Typically, an enterprise has insufficient experience and references in relation to the selection of the needed maturity model (cf. [Me09a]). Therefore, the following criteria for selecting a maturity model are proposed by [Me09a].

PHASE	DECISION PARAMETERS	CHARACTERISTIC			
Select model	Origin	Academic		Practitioner-based	
	Reliability	Untested	Verified		Validated
	Practicality	General recommendations		Specific improvement activities	
	Accessibility	Free		Charged	
	Design mutability	None	Form	Functioning	Form and functioning
	Application method	Self-assessment	Third-party assisted		Certified professionals
Prepare deployment	Driver / Responsibility	Business		IT	
	Realization	Informal appraisal		Formal assessment project	
	Application area	Specific entity		Multiple entities	
	Respondents	Management	Staff	Business partners	Combination
	Training	None	Basic		Extensive
Apply model	Execution	Go		No go	
	Frequency of application	Non-recurring		Repeated	
Take corrective actions	Target setting	Uncoupled		Coupled	
	Implementation	On the fly		Project	
	Implementer	Line organization	Staff organization		Externals

Table 3.: Decision parameters during maturity model application [Me09a]

- **Origin:** This decision parameter identifies the origin of the model. Mettler distinguishes two dimensions – academic and practitioner-based maturity models. This classification criteria was already introduced and discussed in this thesis in Section 2.2.
- **Reliability:** This decision parameter determines how well the maturity model has been evaluated. It can be untested, verified, or validated. A validated maturity model was reviewed concerning its suitability for the operation purpose, e.g. the improvement of EA management. A verified model has provided the evidence that it meets the requirements to the model. For example an validated maturity model has defined improvement activities for EA management, but it was not verified that these activities lead to real improvements in EA management. Obviously, an organization prefers tested and reliable approaches. If information about the validation, or verification of the maturity model are available, they will be comprised in the selection process. For example this information can be a result of a former application of

the maturity model or a description of the validation or verification process.

- **Practicality of recommendations:** This decision parameter determines the level of recommendations. They can be specific improvement activities or more general recommendations. This property is important for the scalability of the issues. Obviously, an organization prefers specific improvement activities, which meet the current situation and the needs. If these specific improvement activities are not available, the organization will use general recommendations to derive special improvement activities concerning the current situation. However, the derivation of special improvement activities from general recommendations is associated with greater expenditure.

- **Accessibility:** This decision parameter determines if the model is free for use or not. This criteria is similar to the dissemination characteristic of the developers perspective. If the maturity model is free for use, there is probably no responsible organization or person to solve emerging problems during the assessment. In contrast, a charged model has an responsible organization, which can help to solve the emerging problem during the appliance, but demands a financial investment.

- **Design mutability:** This decision parameter determines the convertibility of a maturity model elements and its ease of integration in an existing organizational model base. The maturity model can define options for customization or configuration in the form and / or functioning. For example an maturity model can define different strategies how to deal with not fulfilled requirements. A maturity model, which provides a great number of possibilities in customization, can be better tailored to the organizations situation. An increasing number of possibilities in customization will result in a higher complexity and more expenditures for the customization.

- **Application method:** This decision parameter classifies the maturity models by the way they are applied, e.g. as self-assessment, as third-party assisted assessment, or with the help of certified professionals. This criteria was already discussed on page 26.

Phase: Prepare deployment After a suitable model was selected, the *prepare deployment* phase starts. This phases comprise decision parameters concerning the preparation of applying the maturity model.

- **Driver / Responsibility:** This decision parameter is concerned with the potential sponsor or responsible person for the application of the maturity model. The maturity model have to meet the requirements of the sponsors.

- **Realization:** This decision parameter defines the formality of realization, e.g. an informal versus a formal assessment. An informal assessment is performed on an ad-hoc basis. There is not much preparation to support the application of the maturity model. This kind of application provides is fast and flexible, but does not guarantee a successful application of the maturity model. The formal assessment is known through the organization. It is prepared and accepted by all organizational units.

This kind of assessment is much more time-consuming, costly, and inflexible, but the assessment project gets all needed information to secure a successful application.

- **Application area:** This decision parameter determines the scope of the corresponding application area. The area of application depends on the organizations goals. Depending on this target, the model have to be applied in a specific entity or multiple entities.
- **Respondents:** This decision parameter is concerned with the location of the respondents. The respondents are already defined by the model. They have to be involved with regard the organization's goal concerning the application of the model.
- **Training:** This decision parameter determines, if a training with relevant stakeholders is detained in a basic or extensive way or not. The adjustments of the maturity model and data collection for the assessment requires much experience.

Phase: Apply model After the model was deployed two decision parameters are made for the appliance of the maturity model can be identified.

- **Execution:** This decision parameter refers to the final decision on applying of the models – go or no-go. This is an internal management decision of the organization and therefore it does not refer to the properties of the model.
- **Frequency of application:** This decision parameter refers to the frequency of maturity models application and the objective of the company– continuous improvement and assessment vs. unique assessment. Within this parameter the decision about possibility and number of recurring applications are made. Maturity models can support a recurring application. If an organization has opted for a recurring assessment, it will prefer models that support this kind of application containing rules and recommendations for future developments. An example for such a model is the AMM [St05], which gives specific recommendations for the improvement in respect to an recurring appliance.

This aforementioned phase contains only straightforward decisions concerning the application of a maturity model. They refer to internal decisions and processes of the company (property-independent). Thus, the two identified decision parameters – *execution* and *frequency of application* – are not relevant for the analysis and classification approach developed in this thesis and therefore this phase defines no additional criteria for classification.

Phase: Take corrective actions In the phase *take corrective actions* the results of the appraisal are critically reflected [Me09a].

- **Target setting:** This decision parameter is concerned with the progress on maturity. This progress can be coupled or uncoupled to the regular target system.
- **Implementation:** This decision parameter defines the implementation of the improvement activities. These improvement activities can be performed on the fly or

as a specific project. A project is necessary for large and extensive changes, because it provides well-defined responsibilities and includes controls over the success of the implementation.

- **Implementer:** Decision about who should realize the corrective actions. The choice of the implementers depends on the available resources. The line organization has the advantage that the workforce, who implement the corrective actions stay in their normal organizational environment. However, conflicts can occur because the workforce is still responsible to their organization. The staff organization ensures that the employees are only accountable to the implementation of the corrective actions. This organizational structure requires enough available workforce. If an organization has not enough staff they can source the corrective actions out to an external. The implementation through externals or a staff organization leads to higher expenditures.

These decision parameters are entire made by the organization. They are not part of the characteristics of the maturity model. Thus, they provide no additional criteria for the classification. Nevertheless, they are substantial for an successful application of the maturity model, and are therefore taken up in the case study in the Section 5.

3.1.3. Evaluation of classification approaches

At this point the aforementioned classification approaches are recapitulated and their content is evaluated for reuse in the development of an analysis and classification approach for maturity models.

The classification approach by Steenbergen categorizes the maturity models only in respect to the representation of maturity. Three types of maturity representation were identified – the staged, the continuous, and the focus-area representation. Additionally, Steenbergen claims that *focus oriented models* are more flexible than the staged and the continuous models [St05].

Mettler provides multiple criteria for a general classification of maturity models. The potential criteria were discussed in Section 3.1.2, some of the criteria of Mettler are reused in the approach presented in this paper with additional adaptations.

In general the presented criteria offer options for the analysis of the structure (cf. [SBB07]) – and general aspects of the models, e.g. *design process* and *accessibility* by Mettler [Me09a], but an analysis and classification of scope of the maturity models and the key aspects of the assessment is not possible with the identified approaches. Thus, an classification of the scope of EA management maturity models is needed.

3.2. The analysis and classification approach of the thesis

The objective of this section is the development of an analysis and classification approach for EA management maturity models. Therefore, the criteria identified in Section 3.1 are reused and adapted. Additionally, other criteria are identified, introduced, and explained.

3.2.1. General and structural aspects

An overview about the reused and additionally identified criteria and the adaptations is given in Table 4. In the following, these identified criteria are classified into general and structural aspects of maturity models. The criteria was selected in respect to the importance for the selection of a maturity model by an enterprise and availability of information for the identification of this criteria. General aspects of maturity models are criteria con-

TYPE OF ASPECT	CRITERIA	REFERENCE	ADAPTATIONS
General	Design process	[Me09a]	None
	Design product	[Me09a]	None
	Maturity definition	[Me09a]	None
	Practicality	[Me09a]	See page 32
	Form of assessment	Additional	See page 32
Structural	Maturity representation	[SBB07]	None
	Number of stages	Additional	See page 32
	Higher-level process categories	Additional	See page 33
	Granulation	Additional	See page 33

Table 4.: Reused and additional criteria concerning general and structural aspects

cerning the foundation and background. They influenced the properties of the model and these criteria bases on the decision parameters of the design process. In particular, Mettler identified criteria of general aspects in the perspectives *maturity model development* (cf. Table 2) and *maturity model application* (cf. Table 3).

Structural aspects are criteria regarding the functioning of maturity models, i.e. the way how maturity is represented or the number of stages. Some of these structural aspects were already identified in Section 2.3. The classification approach by Steenbergen influences this part of the analysis approach: describing the maturity representation.

- **Practicality** – The identified dimensions of this decision parameter by [Me09a] are *general recommendations* and *specific improvement activities*. With regard to the identified activities of EA management in Section 1.3.1 and the linked deliverables this criteria is supplemented with dimension of *general recommendations and deliverables* and a combination *specific improvement activities and deliverables*.

- **Form of assessment** – The *design product* was already identified. This criteria reviews the concrete form of the assessment. With regard to the models three types can be distinguished: general requirements, a questionnaire, or a matrix/ scoreboard. General requirements define a state of the process to reach a certain level of maturity, e.g. *EA plans have to be annually updated*. A questionnaire defines questions concerning the level of maturity, which can be answered with *yes* or *no*, e.g. *Are the EA plans annually updated?*.

- **Number of stages** – This criteria describes, if the model has a fixed or flexible number of maturity or capability levels. Additionally, it identifies the number of stages filled with content, as in most cases the first maturity or capability level of an maturity

model has not content, e.g. the U.S. GAO – EAMMF [Go03] (cf. Figure 5). Thus, this criteria has three characteristics, below five levels, five respectively more than five levels, or a flexible number of maturity levels.

- **Higher-level process categories** – This criteria covers whether the KPAs are grouped and combined, or not. Some of the models group the KPAs by the order of improvement, or the membership to sub-processes. These categories can help an organization to identify dependencies.

- **Granulation** – The level of detail of a model directly influences its potential to include all important aspects of the subject under consideration, e.g. the real EA management world. Nevertheless, more details always come along with more expenses regarding the data collection, interpretation, and reporting. As an heuristic for the degree of granulation the number of assessment items (e.g. questions or requirements) may be used. However, the collection and calculation of this number is very difficult, because is not always clear whether a separate statement identified two requirements, or is regarded as one. Therefore, the basic objects for the assessment are considered. These objects are the statements of the KPAs and the maturity levels if an continuous model for example defines five maturity levels and ten KPAs, it has 50 assessment objects. The criteria of granulation differentiates between low granulation with less than 50 items, middle (50-100 item), and high granulation with more than 100 items.

MODEL	NUMBER OF ASSESSMENT OBJECTS
U.S. GAO – EAMMF	31
NASCIO	40
IFEAD – E2AMM	65
OMB – EAAF	65
ITGI – *COBIT*	200
DyA – AMM	134

Table 5.: Model's number of assessment objects

The final classification framework for general aspects of maturity models is shown in Table 6.

The final classification framework concerning the structural aspects of maturity models and their characteristics are shown in Table 6.

3.2.2. Aspects with regards to content

The primary objective of classifying maturity models regarding their scope is the recording of the substantive issues in EA management. As a result, an analysis and classification framework of the scope of maturity models was created. This allows a detailed evaluation of the application at an industrial partner. The scope of the maturity models (what it assesses) is defined within the assessment objects, e.g. the requirements, questions, or the

CRITERIA	CHARACTERISTICS			
Design process	Theory-driven	Practitioner-based		Combination
Design product	Textual description of form	Textual description of form and functioning		Instantiation (Assessment tool)
Form of Assessment	General requirements	Questionnaire		Matrix / Scoreboard
Maturity definition	Process-focused	Object-focused	People-focused	Combination
Practicality	General recommendations	General recommendations and deliverables	Specific improvement activities	Specific improvement activities and deliverables

Table 6.: General aspects of maturity models

CRITERIA	CHARACTERISTICS		
Maturity representation	Staged	Continuous	Focus area
Number of Stages	<5	≥ 5	Flexible
Higher-level process categories	Not defined	Defined	
Granulation	Low	Middle	High

Table 7.: Structural aspects of maturity models

scoreboard. In the following, a category system is established, which is the basis for the classification framework of the scope. This category system covers various aspects of the EA management process.

The definition of EA management serves as staring point for the development of the classification framework concerning the scope. One aspect of EA management is the integration with other enterprise-level management processes, which is shown in Figure 1 and mentioned in the EA management definition at page 2. There is an information exchange in both directions between EAM and enterprise-level management processes. In this case, integration refers to the exchange of information between the EAM and the other enterprise-level management processes. This exchange of information takes place in both directions. The enterprise-level management processes, which are derived from Figure 1 are:

- IT Project Lifecycle is an enterprise-level management process concerned with the management within a single project. It includes all project management activities, starting from the project definition and finishing with the roll out.
- Strategy and Goal Management is an enterprise-level management process concerned with managing objectives and strategies of the enterprise.
- Project Portfolio Management is an enterprise-level management process concerned with prioritizing projects and initiatives. This includes IT investment decisions.

- Synchronization Management is an enterprise-level management process concerned with the monitoring and synchronizing of different projects continuous changes. This includes maintenance of the current IT infrastructure and applications.
- IT Architecture Management is an enterprise-level management process concerned with defining an managing the IT architecture.
- Requirements Management is an enterprise-level management process concerned with the collection and processing of demands on applications and infrastructure from business and IT.

These enterprise-level management processes are used as subcategories for the enterprise-level management process category (cf. Figure 15). Other aspects can be derived from a

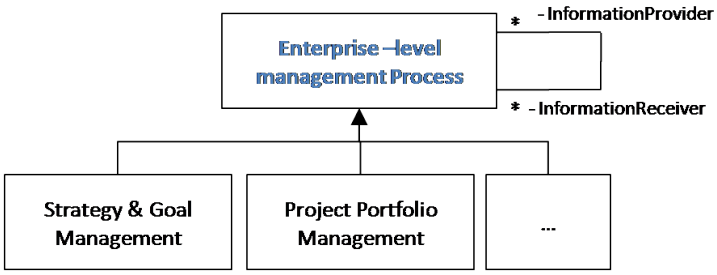

Figure 15.: Information Exchange between Enterprise-level management processes

general business process definition. Each process is defined as a number of activities which are linked with roles, inputs, and outputs (cf. [BF02]). Thus, also the EA management process consists of a series of interconnected and distinct activities and these activities "can cause and influence" each other [HN05]. The activities of EA management were already identified in Section 1.3.1. They are used as subcategories for the activity category (cf. Figure 16).

As mentioned before, these activities are linked with roles, which are involved in the ex-

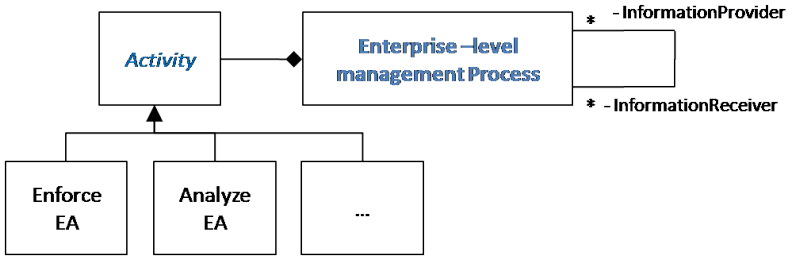

Figure 16.: EA management activities

ecution of an activity, either as participant or as a responsible manager (cf. Section 1.3.1). Subcategories concerning the aspect of the involved roles can not be clearly given, because there are no standardized and commonly accepted roles in the area of EA management [Be09]. So it is assumed that the roles defined by an agency significantly differ from

the roles defined by an enterprise. Therefore, the subcategories are extracted from the maturity models and similar roles are classified within one group.
The activities are additionally linked with defined input e.g. documents, information, and guidelines, to produce a defined output e.g. again documents, software etc. These inputs and outputs are called EA deliverables in the following. The subcategories for the EA deliverables can also be derived from the EA management activities [BMS09].

- The *guideline* is an EA deliverable that does not directly influence the EA, but it influences the development of the EA through restrictions, constraints, and requirements to the process. The guideline was derived from the definition of EA management in Section 1.3.1 and excluded from the *target EA*, which is the result of the activity *envision EA*.
- The target EA was derived from the activity *envision EA* (cf. [BMS09]). The target EA is in the following the definition of future architectures, e.g. business architecture and infrastructure architecture.
- The *EA report* can be derived from the activity *document EA*. The provided documentations of the current EA always refer to the concerns of the EA management, like a report(cf. [GHM08]).
- The *EA Plans* are the result of planning the EA. The EA plans include the implementation of the EA through defined projects that will not have a negative impact on each other.
- The *EA analysis results* are the output of the activity *analyze EA*. They refer to the different properties of the EA, e.g. compliance with EA guidelines, costs, flexibility, etc. and they are related to the analysis of the current EA, as well as to predictions about EA scenarios.

The aspects concerning the EA deliverables and roles with some examples are shown in Figure 17. The next aspect is the support of activities by tools. The activities of a process

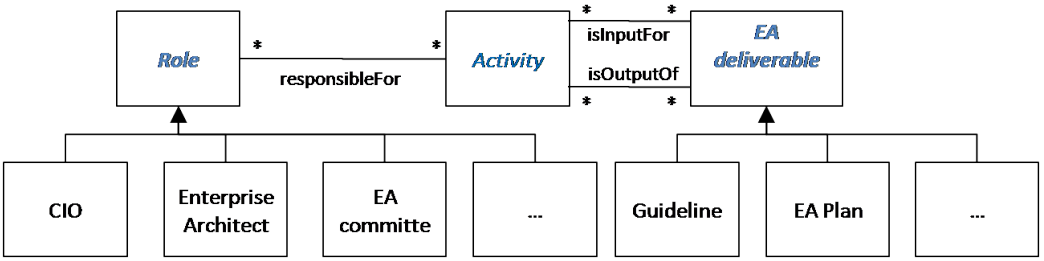

Figure 17.: Involvement of roles and EA deliverables in EA management activities

can be supported by the use of software tools (cf. [HN05]). Besides the software tools, there are a variety of other tools supporting EA management, like frameworks e.g. FEAF as a framework for the development of a federal EA [Ch99]. Thus, the category was augmented to a more general perception of the term *tool*. In this case a tool is everything that supports activities through (partly) automation , e.g. like a software tool, or through

generally accepted specifications and methods, e.g. like a standard or framework. The identified tools are derived from [HN05, Go03]. They are especially:

- A *framework* is a reusable system that consists of semi-finished components, and their rules for interaction(cf. [HN05]). Thus, a framework provides a topology for the EA.
- A *software tool* is a application that supports an activity through partly or complete automation. It can serve as the repository or design tool, e.g. ARIS for the EA deliverables.
- A *standard method* is a set of procedures for the development of EA deliverables. It can be compared to a process model in software engineering, e.g. the rational unified process.

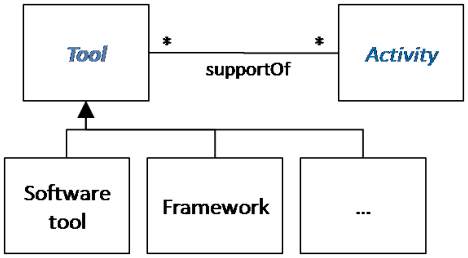

Figure 18.: Support of activities by tools

The overall picture of elements and their relationships is described in Figure 19. The five objects *enterprise-level management processes*, *EA deliverables*, *tools*, *activities*, and *roles* with their relations to the EA management are used as the highest classification criteria. The classification also shows examples for the identified sub elements, which are grouped within these categories. The resulting category system represents the basic tool for the analysis, and ensures the inter-subjectivity of the results.

Based on the identified highest levels in encoding, an additional classification framework for analyzing the content of maturity models was created. The part of the classification framework concerning the scope is shown in Table 8. The entity *activity* was excluded from the table, because this aspects is already identified through the criteria *maturity definition* in Table 6. The detailed specification of the maturity model concerning the identified subcategories is shown in Section 4.

CRITERIA	CHARACTERISTICS		
Integration with enterprise-level management processes	Not defined	Defined	Focus
Involvement of roles	Not defined	Defined	Focus
Involvement of EA deliverables	Not defined	Defined	Focus
Involvement of tools	Not defined	Defined	Focus

Table 8.: Key aspects of the maturity model's scope

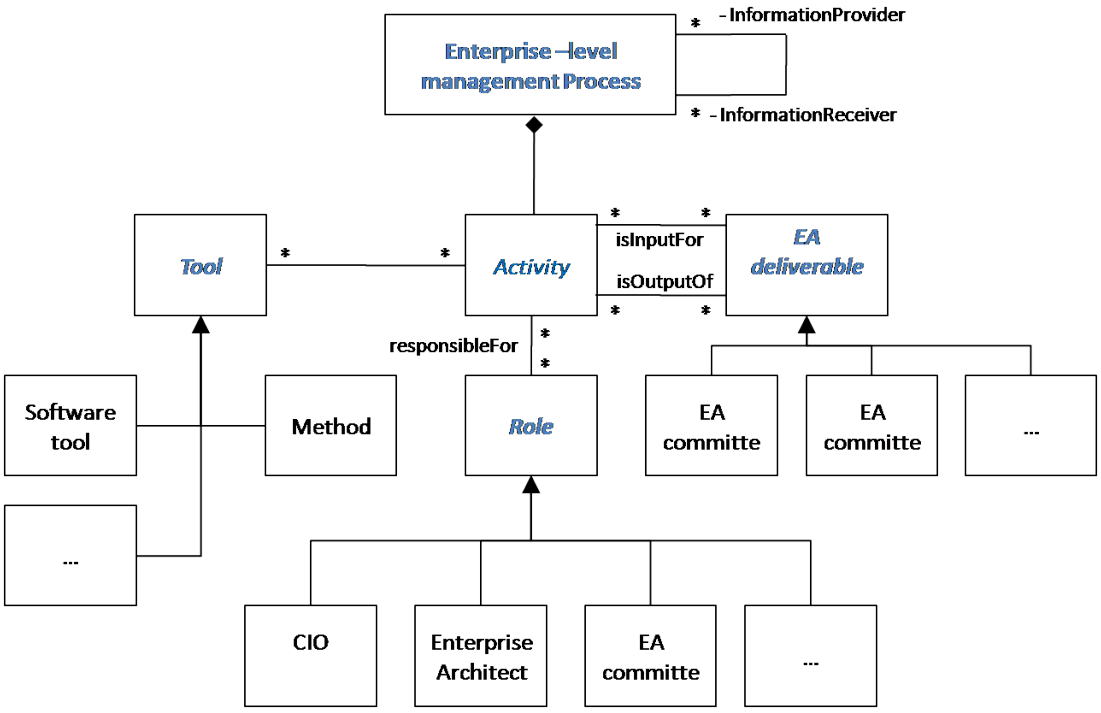

Figure 19.: Ontology for content analysis

4. Applying the classification approach

The objective of this section is to validate the developed analysis and classification approach for EA management maturity models. Therefore, the developed analysis and classification approach is applied to the previously selected maturity models in Section 4.1. Based on these results, the models are classified in Section 4.2. Finally, the developed analysis and classification framework is evaluated and critically reviewed in Section 4.3.

4.1. Analysis of existing EA management maturity models

In order to perform the analysis of general and structural aspects the documents relating to the maturity models are investigated. The documents usually consist of two parts – the assessment document and the maturity model.

One part is the documentation of the model, which includes information on the development, the form (structure), and the application of the model. However, not all information needed for the analysis is contained in this documentation. Thus, other sources have to be involved. The other part contains the model itself including requirements used for the assessment. This part is evaluated in the content analysis.

The maturity models have some similarities concerning the analysis criteria of Mettler. All models focus on the specific issue of EA management. The oldest model was developed in 2003 (U.S. GAO – EAAF) and the average age of the models reviewed in this section is approximately three years. The documents of the models examined here are publicly available, with one exception the OMB – EAAF [Of08], whose assessment document is only online available for U.S. agency staff only. The limitations regarding the analysis and classification of EAAF due to the restricted access are discussed in Section 4.1.4.
The selected models are investigated concerning their characteristics in the following.

4.1.1. U.S. GAO – Enterprise Architecture Management Maturity Framework

The investigated version of the U.S. GAO – EAMMF is version 1.1, which was released in 2003 [Go03]. The following information concerning the general and structural aspects, as well as the aspects with regards to content were taken from the documentation.

General aspects

The development of the U.S. GAO – EAMMF is based on the results of a research project concerning IT management practices and evaluations of agency IT management performance [Go03]. During this research the U.S. GAO identified a set of essential management disciplines among them was EA management [Go03]. Therefore, the EAMMF project was

CRITERIA	CHARACTERISTICS
Design process	Practitioner-based
Design product	Textual description of form and functioning
Form of Assessment	General requirements
Maturity definition	Combination
Practicality	Special activities with EA deliverables

Table 9.: General aspects of U.S. GAO – EAMMF

launched, aiming at an instrument for EA management. The first version of EAMMF was released in 2002. The model was updated in 2003 to version 1.1 by asking departments and agencies about the experience with the EAMMF, and noticed strengths and weaknesses. 63 of the 116 polled agencies responded and provided over 300 comments, suggestions, and concerns that were incorporated in version 1.1. Thus, the design process is classified as practitioner-based.

The EAMMF has a textual description of form and functioning. The documentation contains explanations concerning the form, including maturity levels and critical success attributes. It describes the general properties of the model, such as the dependencies between stages, KPAs (core elements),critical success attributes, and the compatibility with other frameworks typically used by U.S. agencies as e.g. FEAF. The functioning of the model is explained with regard to the use as a roadmap for EA management improvement or as a tool for EA management maturity assessment.

The model defines requirements to assess the EA management maturity of an organization. An exemplary requirement is: ”EA plans call for describing both the ’as-is’ and the ’to-be’ environments of the enterprise, as well as a sequencing plan for transitioning from the as-is to the to-be” [Go03].

The maturity definition of the model is a combination of the object-focused and process-focused definitions. The EAMMF has 12 KPAs, which define requirements to objects. These requirements can be found at the stages 2, 3, and 4 within the critical success attribute of *demonstrating the satisfaction of commitment*. These object-focused KPAs are cumulative. The requirement at stage 2 is that the EA deliverable ”EA plans call for describing both the ’as-is’ and the ’to-be’ environments” [Go03]. At stage 3 the EA deliverables should now describe the ’as-is’ and ’to-be’ EA, as well as the transitioning. All other KPAs have a process-focused orientation. For example the KPA ”EA products and management processes undergo independent verification and validation” [Go03] is obviously process-focused.

The EAMMF defines special activities, which reference EA deliverables. For example the committee representing the enterprise serves as a *steering group* and ”is responsible for guiding, directing, and approving the EA plans and products, including significant changes to either” [Go03]. This shows that the model defines activities, which are to be performed by a certain role and use certain objects. The identified general aspects of the U.S. GAO – EAMMF are summarized in Table 9.

Structural aspects

The EAMMF defines a staged approach. It determines five stages of maturity. The first maturity stage defines no requirements for an assessment, therefore each organization reaches at least the maturity level 1 of EAMMF. The other four stages have defined requirements for improving the established EA management.

The model defines four types of process categories, called *critical success attributes*. The process categories defined by the EAMMF are *demonstration of commitment*, *provision of a capability to meet the commitment*, *demonstrating the satisfaction of commitment*, *verification of the satisfaction* [Go03]. They describe the phases of improvement within each stage. Thus, they support an organization in EA management improvement planning by proposing a implementation sequence. The development of EA management through the phases in stage 2 is exemplified in the following. The example underlines the classification as sequent process categories.

1. Demonstration of commitment: An organization shows the commitment that it supports the EA management foundation (stage 2) by providing resources and involving stakeholders.

2. Provision of a capability to meet the commitment: To meet the commitment the foundation is built by establishing of a chief architect and an EA management program office.

3. Demonstrating the satisfaction of commitment: An organization shows the success and the functioning of the foundation by developing and using EA plans.

4. Verification of the satisfaction: The foundation is verified and evaluated through assessing the EA progress, the quality, etc.

The granulation of the model is low as it defines only 31 assessment objects (lowest value of all maturity models cf. Figure 5), but within each KPA the model provides more than one requirement. The first KPA *adequate resources exists* defines for example three actions. The first is to secure funding for EA management support, the second is to hire the right people with proper knowledge, and the third is to acquire the right tools for EA management support. The structural aspects are summarized in Table 10.

CRITERIA	CHARACTERISTICS
Functioning	Staged
Number of Stages	<5
Higher-level process categories	Defined
Granulation	Low

Table 10.: Structural aspects of U.S. GAO – EAMMF

Aspects with regards to content

This paragraph is considered with the scope of the EAMMF. Therefore, the 31 KPAs were analyzed in respect to the developed category-system of Section 3.2.2.

The EAMMF assesses the EA management in respect of the integration with two enterprise-level management processes. These two processes are namely IT security and project portfolio management and the focus is on the involvement of IT security. This enterprise-level management process is an integral part of the stages two to four. In contrast the Project Portfolio Management is only assessed within one KPA. Beside the integration of these enterprise-level management processes, the EAMMF provides a number of KPAs regarding the integration of the business, but only in the way of defining the same terms. This kind of integration is classified as a necessity for the communication processes and not for the integration of an enterprise-level management process.

The responsible and participating roles are an major aspect of the EAMMF, because all of the process-focused KPAs, except one, define responsibilities or involve roles. Therefore, the EAMMF defines the most different roles as compared to the other investigated maturity models. There are eight different roles defined and identified, on the one hand commonly accepted roles, e.g. the CIO or CEO, on the other hand very specific roles, e.g. the Configuration Manager. The EAMMF defines four specific in respect to the EA management, which are the EA committee, the Architect, the program office, and an special audit team for the EA. Therefore, the maturity model has an explicit focus in respect to the aspect of involved roles.

The definition of EA deliverables and how they are incorporated in a certain activity is another major aspect of the EAMMF. The model defines already a number of object-focused KPAs concerning the properties of EA deliverables. Additionally, the majority process-oriented KPAs involve these EA deliverables. The EAMMF has implemented all EA deliverables, which were defined in Section 3.2.2.

The EAMMF also recommend the use of tools. It defines a KPA, which deals with the use and the advantages of using frameworks, software tools, and standard methods. Thus, it covers all identified sub-categories of tools.

The model also covers all identified activities. Even the object-focused KPAs refer implicitly to the activities of EA management. For example, the EA plan is the result of the activity plan EA. Therefore, the demands at this object can be used to define the necessary tasks of the activity plan EA. This activity is also only indirectly assessed by these object-focused KPAs. The EAMMF defines no separate process-oriented KPA in respect to the activity plan EA. In addition, the model defined KPAs for all the other activities, except envision EA. However, the KPAs partly describe more complex processes, which relate to more than one activity.

The key aspects of the model are summarized in Table 11. The aspects of EA deliverables and roles are classified as a focused aspects, because these two aspects were taken into account by the majority of the KPAs.

CRITERIA	CHARACTERISTICS
Integration of enterprise-level management processes	Defined
Involvement of roles	Focus
Involvement of EA deliverables	Focus
Involvement of tools	Defined

Table 11.: Key aspects with regard to content of U.S. GAO – EAMMF

4.1.2. DyA – Architecture Maturity Matrix

The investigated version of the DyA – AMM is the initial release from May 2005 [St05]. The following information concerning the general, structural, and aspects with regards to content were taken from the documentation [St05] and a conference paper published in 2007 (cf. [SBB07]).

General aspects

The design process was partly theory-driven with regard to the functioning of the maturity model. The authors searched for models that were not build around the standard five maturity levels [SBB07]. Thus, they found a focus-area oriented model from test process improvements. Whereas the roots of the AMM are the theoretical foundations of test process improvements (cf. [KP99]), the content and the positioning of the maturity stages is influenced by practical experience of architectural processes in various organizations. Therefore, the development process of the AMM is a combination of theory-driven origin and a practitioner-based process.

The design product of the AMM is a textual description of form and functioning. The form is described by explaining the concept of KPA. The AMM defines a KPA as a "growth path for the maturity within a certain area" [St05]. The functioning of the model is explained with regard to the use of the model. Each KPA provides a number of questions. If all questions of an KPA can be answered with *yes* the respective stage of maturity is reached. The model also defines two additional rules for utilization. An organization should be able to perform an EA management assessment with the information about the form and functioning.

The assessment is performed with a questionnaire. The questionnaire contains a general description for every KPA supplemented by descriptions of the single stages. Every stage of an KPA defines a number of questions to satisfy the requirements resulting from the description. The assessment is accomplish by answering the questions with yes or no. This helps the enterprise to easily identify the requirements and to clearly answer the questions. Thus, each question refers only to one of the requirements of the description.

The maturity definition of the model is entire process-focused. All KPAs and requirements are assessing the capabilities of activities in the context of EA management. According to [St05] EA management is "a set of principles and models that guide design and implementation of processes, organizational structure, information flows and technical in-

frastructure in an organization". Due to the process focus of the approach the questions of the AMM don't define any requirements to the EA deliverables, or workforce.

The practicality of the AMM is grouped as specific improvement activities. Although some EA deliverables e.g. guidelines are defined, most questions do refer to them as a part of the assessment. The major number of questions assess the involvement of other enterprise-level management processes or the involvement of roles with EA management. "Is architecture used to make design choices within individual projects?" [St05] is an example for a typical question. The general aspects of the AMM are summarized in Table 12.

CRITERIA	CHARACTERISTICS
Design process	Combination
Design product	Textual description of form and functioning
Form of Assessment	Questionnaire
Maturity definition	Process-focused
Practicality	Specific improvement activities

Table 12.: General aspects of DyA – AMM

Structural aspects

The functioning of the AMM was already identified as focus-area oriented (cf. Section 2.2). Thus, each KPA of the AMM defines its own number of maturity levels. The maximum number of levels is four (A,B,C,D) and the minimum is two (A,B) [St05]. Obviously the AMM defines no higher-level process categories. The assessment of the AMM is grouped as fine grained as the 18 KPAs of the AMM provide 137 questions to assess the EA management maturity of an organization. The structural aspects of the AMM are summarized in Table 13.

CRITERIA	CHARACTERISTICS
Functioning	Focus area
Number of Stages	Flexible
Higher-level process categories	Not defined
Granulation	fine

Table 13.: Structural aspects of DyA – AMM

Aspects with regards to content

This paragraph is considered with the scope of the AMM. Therefore, the 134 Questions grouped in 18 KPAs were analyzed in respect to the developed category-system of Section 3.2.2.

The AMM assesses the EA management approach in respect of the involvement of several enterprise-level management processes. It defines many questions concerning information flows between these enterprise-level management processes through organizational structures. In particular the EA management is assessed against the integration with (business) requirements engineering, the project lifecycle, and synchronization management. Each of these is directly assessed by a single KPA. Furthermore, also questions of other KPAs reference these exchange of information with the enterprise-level management processes. Approximately one third of the questions imply a reference to other enterprise-level management processes and therefore it is classified as a major aspect.

The second major aspect is the definition of responsible and participating roles. By focusing on the exchange of information through organizational structures, it is obviously that a lot of questions relates to defined roles. Approximately the half of the questions involve a role, which is either derived from the EA management division, e.g. a chief architect or the EA program office, or it is a derived from another enterprise division, e.g. system developers. The majority of the questions concerning the involvement of roles are related to the chief architect. Thus, the AMM defines the chief architect as a key role within the EA management.

The AMM also incorporates a variety of EA deliverables, e.g. guidelines, the target EA, analysis results, and the EA plan. The EA analysis results are very special to this maturity model, because they are defined through statistics and forecasts in relation to the current EA and EA scenarios. Although, there are activities concerning the current situation of the EA, there is no explicit EA deliverable in the form of a EA report. In general, EA deliverables are rarely taken into account in the questions.

The AMM recommends the use of software tools and methods to support the EA management. So the use of repositories should grant consistency of the different EA deliverables, as well as the use of integrated software tools for an effective and efficient development of EA deliverables, e.g. the target EA. Methods have been considered primarily in terms of standardization and their consistent implementation throughout the enterprise and the enterprise-level management processes. The AMM covers all identified EA management activities and there were no specific characteristics identified.

The aspects with regards to content are summarized in Table 11. The aspects of enterprise-level management processes and roles are classified as a focused aspects, because these two aspects were taken into account by a majority of the questions.

CRITERIA	CHARACTERISTICS
Integration of enterprise level management processes	Focus
Involvement of roles	Focus
Involvement of EA deliverables	Defined
Involvement of tools	Defined

Table 14.: Key aspects with regard to content of DyA – AMM

4.1.3. IFEAD – Extended Enterprise Architecture Maturity Model

The investigated version of the E2AMM is version 2.0, which was released in 2006 [Sc06]. The following information concerning the general, structural, and aspects with regards to content were taken from the documentation.

General aspects

As mentioned in Section 2.2 this model has it's roots in practice. The design process is not described in any document. It is assumed that the model is derived from the E2A, because many requirements assess EA management against those E2A definitions.

The documents do not contain a description of the functioning. There is simply a matrix for the assessment, presenting the form. There are no rules defined for the determination of the organization's overall maturity. Thus, the usability is restricted due to missing description of the functioning.

The assessment is performed by fulfilling requirements. Each KPA defines several requirements at the different stages. A typical requirement looks like: "measurement structure in place to manage Extended Enterprise environment" [Sc06]
The E2AMM defines a entire process-focused approach. It provides a path for EA and procedural improvements of EA management within an organization [Sc06]. Thus, all KPAs and requirements are assessing the EA management concerning capabilities of processes. Some requirements of the E2AMM are only general recommendations concerning EA management, e.g. "Executive management participating in the E2A optimization process" [Sc06], but most define special activities for improving and assessing the EA management, e.g. "Business initiatives are continuously reflected to the technology impact" [Sc06]. The general aspects are summarized in Table 15.

CRITERIA	CHARACTERISTICS
Design process	Not known
Design product	Textual description of form
Form of Assessment	Requirements
Maturity definition	Process-focused
Practicality	General recommendations

Table 15.: General aspects of IFEAD – E2AMM

Structural aspects

The E2AMM is a continuous maturity model, defining five levels of maturity. The granulation is grouped as middle, because it defines 11 KPAs and each has five maturity levels, resulting in overall 55 assessment objects [Sc06]. These 55 objects are not grouped within any higher-level process categories. The majority of the assessment objects describe more than one requirement. Therefore, there are over 90 independent requirements to the EA management. The structural aspects are summarized in Table 16.

CRITERIA	CHARACTERISTICS
Functioning	Continuous
Number of Stages	$\geq$5
Higher-level process categories	Not defined
Granulation	middle

Table 16.: Structural aspects of IFEAD – E2AMM

Aspects with regards to content

This paragraph is considered with the scope of the E2AMM. Therefore, the 55 items of the 11 KPAs were analyzed in respect to the developed category-system of Section 3.2.2 [Sc06].

The E2AMM is as aforementioned aligned the to E2A. Therefore, the majority of the requirements are related to the degree of the E2A implementation. Thus, the model is

The assessment of the EA management in respect to the integration with other enterprise-level management processes is one major aspect of the E2AMM. Especially, the integration of business and therefore requirements engineering is recommended. Beside the integration of requirements engineering there is a focus on the project portfolio management, which is directly assessed by two KPAs [Sc06]. Approximately one third of the requirements recommend the integration with other enterprise-level management processes.

The second major aspect of the E2MM is the integration of roles and responsibilities. The defined roles are an essential part of the model, because there are several KPAs for the involvement of these roles e.g. the involvement of the *Extended Enterprise Architecture Program Office*, which is comparable to the EA program office of the U.S. GAO – EAMMF [Go03]. Furthermore, there are requirements within other KPAs which also assess the involvement of roles, e.g. the chief architect [Sc06].

The involved EA deliverables are mostly referred as EA results [Sc06]. Therefore, it is not possible to identify which EA deliverables are linked with a certain requirement. Although, the E2AMM mentions the EA deliverables target EA and and EA analysis results.

The E2AMM features also the use of tools. It assesses the use of software tools, especially repositories, as well as methods, and frameworks. Thus, it defines all tools identified in Section 3.2.2.

The model emphasize on activity analyze EA. Especially seven of the KPAs have implemented recommendations in relation to this special activity [Sc06]. The with regards to content of the E2AMM are summarized in Table 17.

4.1.4. OMB – Enterprise Architecture Assessment Framework

The investigated version of the OMB – EAAF is version 3.0, which was released in December 2008 [Of08]. The latest version is 3.1, which is under a restriction regarding the

CRITERIA	CHARACTERISTICS
Integration of enterprise level management processes	Focus
Involvement of roles	Focus
Involvement of EA deliverables	Defined
Involvement of tools	Defined

Table 17.: Key aspects with regard to content of IFEAD – E2AMM

available assessment tool. The EAAF provides an Excel-sheet for the assessment. This sheet is supplemented by an online assessment tool, only available for U.S. agency staff. The following information concerning the general, structural, and aspects with regards to content are taken from the documentation and the excel-sheet published with the maturity model in version 3.0.

General aspects

There is no information available about the initial design process of the OMB's EAAF. The design product of the EAAF is a textual description of form and functioning. The documentation includes explanations about accomplished changes to the framework and the content of the KPAs. The documentation also include an own section about the assessment process. The assessment process defines that the agency will receive an average assessment score in each capability area, which is grouped as green, yellow, or red [Of08]. This functioning is also implemented in the EA assessment tool.
The EAAF makes extensive use of KPIs [Of08]. Every KPA defines special KPIs, including information how they are measured and the artifacts and informations used for this measurement. Accordingly, the model defines requirements. The requirements are provided by KPIs, which define a certain degree of fulfillment for this KPA.
The EAAF "spans planning, investment, and operations activities required to work in concert to improve agency performance through the management and use of information and information technology" [Of08]. Thus, the model has a process-focused maturity definition.
The model defines specific improvement activities, each linked with special EA deliverables – e.g. an enterprise transition plan or an EA segment report. The description of the aforementioned deliverables is also a part of the EAAF (cf. [Of08]). Thus, the practicality is classified as *specific improvement activities and deliverables*. The general aspects are summarized in Table 18.

CRITERIA	CHARACTERISTICS
Design process	Not known
Design product	Instantiation
Form of Assessment	Requirements
Maturity definition	Process-focus
Practicality	Specific improvement activities and deliverables

Table 18.: General aspects of OMB – EAAF

Structural aspects

The KPAs are grouped in three higher-level process categories – labeled as *capability areas*. The capability areas are *use*, *completition*, and *results*. The use capability area is "establishing the necessary management practices, processes, and policies needed for developing, maintaining and overseeing EA" [Of08]. The completition area reflects the agency's EA deliverables with regard to the target EA so it can be assumed that the KPAs of this area are focusing on the activity of analysis. The result capability area is measures the effectiveness by defining KPAs for the EA and related processes [Of08]. The latter area consists of four KPAs assessing the activity analyze EA. These capability areas support an organization in concentrating on the improvement of special activities.
The EAAF defines five stages and 13 KPAs containing requirements regarding the EA management of an organization. Thus, 75 assessment objects are defined [Of08]. Nevertheless, the granulation is grouped as middle, because many of the requirements are cumulative. Often the same requirement, only differing in a percentage value, is defined in different stages. The structural aspects are summarized in Table 19.

CRITERIA	**CHARACTERISTICS**
Functioning	Continuous
Number of Stages	$\geq$5
Higher-level process categories	Defined
Granulation	Middle

Table 19.: Structural aspects of OMB – EAAF

Aspects with regards to content

This paragraph is considered with the scope of the EAAF. Therefore, the 75 items of the 15 KPAs were analyzed in respect to the developed category-system of Section 3.2.2.

Concerning the integration of other enterprise-level management processes the EAAF focus on the integration of the project portfolio management. The model assesses this process through requirements at the IT investments. There are requirements defined concerning the representation of investments in EA plan and the analysis of the EA management concerning costs and return on investments. The other enterprise-level management process, which is defined by the EAAF is IT-security.

The integration of roles plays a minor role in the recommendations of the EAAF. It mentions three roles, the CIO, the CEO, and the investment review board, and these three are only mentioned within a single KPA.
A major aspect of the EAAF is the definition of EA deliverables and the related requirements. Every KPA of the EAAF references to a corresponding mandate, which results in special EA deliveries. For example an organization using this model is recommended to implement the special EA plans and EA reports of U.S. mandates. Approximately 80 percent of the requirements assess the EA management approach against this laws. Therefore, the usability is very restricted with and organization in private industry.

In contrast to the other models, the EAAF do not generally recommend the use of software tools, methods, or frameworks. However, it requires the implementation of a specific framework, the FEAF. This framework was especially designed for the EA of an U.S. agency and therefore the usability is again restricted for an enterprise.

The EAAF covers all identified activities. These activities are separated by the higher-level process categories. It was identified that the third of these categories reference mainly to the activity analyze EA, whereas the first category reference mainly to envision EA, plan EA, and document EA. The aspects with regards to content are summarized in Table 20.

CRITERIA	CHARACTERISTICS
Integration of enterprise level management processes	Focus
Involvement of roles	Defined
Involvement of EA deliverables	Focus
Involvement of tools	Defined

Table 20.: Key aspects with regard to content of OMB – EAAF

4.1.5. U.S. DoC – Architecture Capability Maturity Model

The investigated version of the DoC – ACMM is version 1.2, which was released in December 2007 [De07]. The following information concerning the general,structural and aspects with regards to content were taken from the documentation published with the maturity model [De07].

General aspects

The design process is not described by the model. The design product of the ACMM is a textual description of form and functioning. Therefore, the model refers to the CMM as foundation. Descriptions of the models KPAs are missing. The functioning of the model is described by a self-explaining scorecard, used for the assessment of the EA management process. In particular, the scorecard combines two complementary methods to determined an organization's maturity level. The first method is focused on the weighted mean maturity level, whereas the second method is focused on the percentage achieved at each maturity level for the nine architecture elements. Thus, also the form of the assessment is identified as scorecard approach.

The maturity definition of the ACMM is process-focused. All KPAs and the included descriptions assess the process (cf. [De07]). The requirements defined by the model are more general at the first stages. But they were evolving to requirements describing special activities, e.g. "Feedback from the IT Security Architecture metrics are used to drive architecture process improvements" [De07]. A relation to EA deliverables or other objects is not discussed in [De07].

CRITERIA	CHARACTERISTICS
Design process	Not known
Design product	Textual description of form and functioning
Form of Assessment	Scorecard
Maturity definition	Process-focus
Practicality	Specific improvement activities

Table 21.: General aspects of DoC – ACMM

Structural aspects

The ACMM has a continuous representation of maturity, and it defines five maturity levels for each KPA. It defines 45 requirements to assess and improve the maturity of the EA management. For this reason the granulation of the model is grouped as low. The KPAs are not grouped in any process category.

CRITERIA	CHARACTERISTICS
Functioning	Continuous
Number of Stages	$\geq$5
Higher-level process categories	Not defined
Granulation	low

Table 22.: Structural aspects of DoC – ACMM

Aspects with regards to content

This paragraph is considered with the scope of the ACMM. Therefore, the 45 items of the nine KPAs were analyzed in respect to the developed category-system of Section 3.2.2.

One major aspect of the ACMM is the intration of enterprise-level management processes. These processes are IT-Security, project portfolio management, and the requirements engineering. Four of the nine KPAs refer to an integration of one of the mentioned processes. The portfolio project management is identified as in other models, e.g. the EAAF [Of08], through the selection of IT-investments [De07].

The ACMM do not assess any EA specific roles, like an architect. The only roles and bodies, which are defined by the model are (senior) management, and procurement staff. Thus, it defines the least number of roles among the investigated Maturity Models.

The EA deliverables referred by the ACMM are the target EA, EA analysis results, and the EA plan. The EA analysis results are referred by the definition of an gap analysis, which identifies the gaps between the current and the target EA. Otherwise, the EA deliverables are not very important for the model.

The ACMM recommends the use of a reference model [De07]. This can be compared to the

sub-category framework, because a reference model needs only some configuration for the use. In addition, the ACMM also recommends the use of software tools for creating and maintaining EA deliverables.

The maturity model supports the most of the defined activities, except the enforce activity, but there are also requirements defined concerning communication processes within the EA management. The foci of the scope are shown in Table 23.

CRITERIA	CHARACTERISTICS
Integration of enterprise level management processes	Focus
Involvement of roles	Defined
Involvement of EA deliverables	Defined
Involvement of tools	Defined

Table 23.: Key aspects with regard to content of DoC – ACMM

4.2. Analysis results

An overview about the results concerning the general aspects of the investigated maturity models is given in Table 24. The design process could not be identified for all the models. The models where the process could be identified, refer mainly to a practitioner-based approach by all. The AMM uses a combination of a practitioner-based and a theory-driven approach, but the questions and the scope of the maturity model were derived from practice [St05]. This suggests a good applicability for these models in relation to the case study.

The most models offer a description about the form and the functioning, except the E2AMM [Sc06]. Beside, these descriptions the OMB – EAAF offers an assessment tool. The investigated version of the EAAF provides this assessment tool in the form of an excel-sheet. The description of the functioning is an essential requirement for the case study, because it have to be clear how the overall maturity level of an organization could be determined.
The majority of the maturity models provide requirements for an assessment. The AMM departs from that idea and offers a questionnaire [St05]. The ACMM provides beside the requirements an scorecard for the assessment. Regarding to the case study the questionnaire is seen as very suitable for the interview.

Al maturity models provide process oriented maturity definition, the only exception is the U.S. GAO – EAMMF, which also defines requirements with an object-oriented maturity definition [Go03]. Concerning the structural aspects some interesting things could be identified. Especially the higher categories should assist companies in improvement activities and to reduce the complexity.

The overview about the structural aspects of the maturity models is given in Table 25. The maturity representation was already examined in Section 2.2 and the maturity models were also selected in respect to their maturity representation. Other differences between

CRITERIA	CHARACTERISTICS			
Design process	Theory-driven	Practitioner-based		Combination
		U.S. GAO – EAMMF		DyA – AMM
Design product	Textual description of form	Textual description of form and functioning		Instantiation (assessment tool)
	IFEAD – E2AMM	U.S. GAO – EAMMF, DyA – AMM, OMB – EAAF, DoC – ACMM		
Form of Assessment	General requirements	Questionnaire		Matrix / scoreboard
	U.S. GAO – EAMMF, IFEAD – E2AMM, OMB – EAAF	DyA – AMM		DoC – ACMM
Maturity definition	Process-focused	Object-focused	People-focused	Combination
	DyA – AMM, IFEAD – E2AMM, OMB – EAAF, DoC – ACMM			U.S. GAO – EAMMF
Practicality	General recommendations	General recommendations and deliveries	Specific improvement activities	Specific improvement activities and deliveries
	IFEAD – E2AMM		DyA – AMM, DoC – ACMM	U.S. GAO – EAMMF, OMB – EAAF

Table 24.: Comparison of general aspects

the maturity models can be found int the granularity and the higher-level process levels. The higher-level process categories are only provided by the U.S. GAO – EAMMF [Go03] and the OMB – EAAF [Of08], but with different backgrounds. The U.S. GAO – EAMMF provides these higher-level process categories to determine an order of the implementation. In contrast the EAAF groups the KPAs in respect to their defined activities. Both approaches are helpful to identify dependencies.

Regarding the scope of the maturity models it was identified that there are difference in the integration of the identified enterprise-level management processes. The integration of requirements engineering, was identified as one of the key aspects of the AMM [St05],

CRITERIA	CHARACTERISTICS		
Maturity representation	Staged	Continuous	Focus area
	U.S. GAO – EAMMF	OMB – EAAF, IFEAD – E2AMM, DoC - ACMM	DyA – AMM
Number of Stages	<5	≥5	Flexible
	U.S. GAO – EAMMF	OMB – EAAF, IFEAD – E2AMM, DoC – ACMM	DyA – AMM
Higher-level process categories	Not defined	Defined	
	Dya – AMM, IFEAD – E2AMM, DoC – ACMM	U.S. GAO – EAMMF, OMB – EAAF	
Granulation	Low	Middle	Fine
	U.S. GAO – EAMMF, DoC – ACMM	IFEAD – E2AMM, OMB – EAAF	DyA – AMM

Table 25.: Comparison of structural aspects

ACMM [De07], and E2AMM [Sc06]. Thus, it can be assumed that these models identify the integration of requirements engineering as a factor of success (cf. Table 26). Regarding the

	Project Lifecycle	**Project Portfolio Management**	**Synchronization Management**	**IT Security**	**Requirements Engineering**
U.S. GAO – EAMMF		✓		✓	
DyA – AMM	✓		✓		✓
IFEAD – E2AMM		✓			✓
U.S. OMB – EAAF		✓		✓	
U.S. DoC – ACMM		✓		✓	✓

Table 26.: Integration of enterprise-level management processes

assessment of the integration of project portfolio management the AMM is the only model,

where this enterprise-level management process is not defined through IT investments. The models can also be distinguished between those integrating IT security (EAMMF [Go03], ACMM [De07], EAAF [Of08]) and those not integrating IT security aspects (AMM [St05], E2AMM [Sc06]). Thus, three of the investigated models define KPAs for assessing the integration of IT security within EA management it was additionally included as an enterprise-level management process. The enterprise-level management processes synchronization management and the project lifecyle was only mentioned by the AMM [St05]. All processes that are not listed in the Table 26, were not identified. Another aspect was the involvement of roles. An overview about the defined roles is given in Table 27. The U.S. GAO – EAMMF models extensively included roles in it's requirements [Go03]. This implies high organizational demands and emphasizes that the EAMMF defines these roles as an important success factor. However, it has to be noted that the EAMMF was developed by an agency, which has clearly defined roles. Obviously, the EAMMF can rely on fixed and predetermined organizational structures. The AMM also features an extensive involvement of roles and bodies [St05]. In contrast to the EAMMF, the roles mentioned by the AMM are referred as normal workforce of the different enterprise divisions, e.g. software developers or system operators. Table 27 also shows that there is no common understanding of roles and no clear definition of roles, which have to be involved in the EA management. Regarding the identified EA deliverables, there are no major differences.

	Audit team	**EA committee**	**Architect**	**Program office**	**Configuration manager**	**Administrators**	**Acquisition workforce**	**System developers**	**Investment review board**	**CEO**	**CIO**	**Senior Management**
U.S. GAO – EAMMF	✓	✓	✓	✓	✓				✓	✓	✓	
DyA – AMM			✓			✓		✓				✓
IFEAD – E2AMM		✓	✓	✓								✓
U.S. OMB – EAAF		✓	✓						✓	✓	✓	
U.S. DoC – ACMM							✓					✓

Table 27.: Identified roles

Although some models put a focus on the integration of these EA deliverables in their assessment, e.g. OMB – EAAF [Of08] and the EAMMF [Go03], all models largely address the same EA deliverables. Also in terms of integrated tools, there were no significant differences identified, except that the EAAF [Of08], and the E2AMM [Sc06] not recommend the any of some architecture framework. The recommend the of a special framework, e.g. the EAAF recommends the FEAF and the E2AMM the E2A. Therefore, the maturity level directly depends on the use of these frameworks, which is regarded as political decision. An overview about the involved tools and EA deliverables is given in Table 28. Regarding the activities of EA management, there is obviously one aspect that is not considered as

	EA DELIVERABLES				TOOLS		
	Guidelines	EA Reports	EA analysis results	EA plan	Method	Framework	Software tool
U.S. GAO – EAMMF	✓		✓	✓	✓	✓	✓
DyA – AMM	✓	✓	✓	✓	✓		✓
IFEAD – E2AMM	✓	✓	✓		✓	✓	✓
U.S. OMB – EAAF		✓		✓		✓	
U.S. DoC – ACMM		✓	✓	✓		✓	✓

Table 28.: Identified EA deliverables and tools

an essential part of EA management, but defined by a number of maturity models within separate KPAs. So the communication of the EA deliverables and results was assessed by all investigated models. Obvious, communication is seen as important factor of success, because if the processes and results are not entirely communicated to the stakeholder, the organization's goals can not be met. This communication aspect is also important for the interdisciplinary nature of the EA management. This aspect is already included in the activity *enforce EA* according to the definition of this activity in Section 1.3.1, but the maturity models distinguish between methods of communication and methods to ensure the compliance with the EA. Thus, the communication activity was separately investigated during the analysis. A summary of the referred activities is given in Table 29

	Envision	Plan EA	Enforce EA	Documentation	Analyze EA	Communication
U.S. GAO – EAMMF	✓	✓	✓	✓	✓	✓
DyA – AMM	✓	✓		✓	✓	✓
IFEAD – E2AMM	✓				✓	✓
U.S. OMB – EAAF		✓	✓	✓	✓	✓
U.S. DoC – ACMM	✓	✓		✓	✓	✓

Table 29.: Defined activities of maturity models

4.3. Validation of the developed approach

The developed approach was suitable to classify all models. Thus, the models differ in some essential features. The main problem was the identification of the design process. Backgrounds of the design process are typically a part of a models documentation, but the design process was not considered by by all assessment documentation.

Also the classification of the identified roles has limitations. The roles were obtained from the investigated maturity models. These roles had different names and different responsibilities. An attempt was made to map them at each other, which was not completely possible. If an mapping to another role was not sure the role was simply included within the categories.

The analysis results concerning the scope are still based on a certain degree of subjectivity. This should be kept as small as possible by proceed through a standardized and theory-founded approaches. However, a certain degree of subjectivity caused by the different terminology of the models could not be totally excluded.

At all the results can be used for an selection of an maturity model which should be applied at the industrial partner.

5. Applying EA management maturity models in practice

The aim of this section is to evaluate the classification framework for EA management maturity models through a case study. At first, a maturity model is selected based on the results of the analysis and classification framework Section 4. Second, a short introduction to the history of the industrial partner, hereinafter referred to as Company A and it's EA management approach is given. As third step, the maturity model is applied based on the EA management process documentation and an expert interview to incorporate the current state of EA management. The interview helps to identify gaps and deviations between the model's definition and the organizations perception of EA management.

5.1. Presentation of the financial service provider

Company A is an international financial service provider founded in the late nineties. It originated from the merge between some large banking companies. In 1999 the newly founded company decided to expand massively in growth markets. Thus, the expansion process focused on Central and Eastern Europe (CEE) and started with the acquisition of a Polish bank. From 2000 to 2002 several financial service providers in CEE – e.g. Bulgaria, Slovakia, Croatia, and Czech Republic – were acquired and merged. In 2005 Company A acquired the great financial service provider Company B.

Company B itself was also the result of the merger of two German banking houses at the end of the nineties. It pursued a strategy of acquisitions in growth markets and bought several banking houses in Europe, but especially in CEE too. Thus, Company B was a competitor of Company A.

A series of restructurings was started after the merge of A and B. One of these was the merge of the IT subsidiaries into one. Within this newly formed organization for each area on IT side one organizational unit was provided, e.g. infrastructure architecture or software development architecture, which directly report to the executive management. Today Company A has an operating income with more than 10,000 million[1] Euros and operates in more than 20 European countries, with more than 150,000 employees[2].

[1] Data as of June, 2009

[2] Includes all full time employees of the subsidiaries, Data as of November 2009

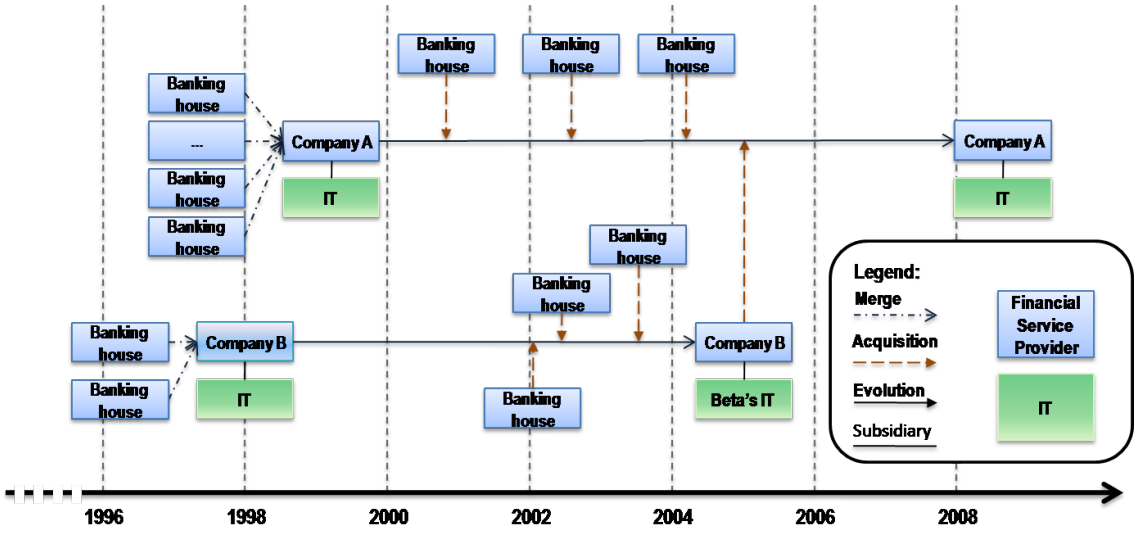

Figure 20.: History of Company A

5.2. The evaluation approach

The case study aims at the evaluation of the analysis and classification framework. Therefore, a maturity model has to be selected, which can be used for an application at an industrial partner. The results can be used to generate assumptions about the suitability of the analysis and classification in practice.

Company A has approached us, because it was interested in an assessment of its EA management approach. At first, his preferences and demands on a maturity model in relation to the classification framework have been collected. The results are summarized in Table 30. Concerning the assessment the industry partner provided a process documentation of the former EA management approach, as well as an interview partner for the assessment of the current approach. The selected model is used for the assessment of the process documentation, as well as for the assessment of current EA management. Regarding the criteria of the classification framework, the preferences were justified as follows. The design process should be practitioner-based, because the model will be accepted faster within the enterprise. Furthermore, the application of a practitioner-based approach is seen as less risky, because the concepts were already approved in practice. The enterprise prefers an assessment tool as design product, but is was also mentioned that at least the form and the functioning of the maturity model have to be described. Regarding the form of assessments the enterprise prefers a version with less expenditures. The maturity model should be directly applicable, e.g. like a scoreboard or a questionnaire. The maturity definition should be process-oriented, because the company wants to get suggestions for the improvement of EA management maturity and not for capabilities of people or maturity of EA deliverables. Finally, the practicality should be as specific as possible. Thus, maturity models with specific improvement activities and deliverables were preferred, but the deliverables were not a must.

CRITERIA	CHARACTERISTICS	
Design process	Practitioner-based	
Design product	Textual description of form and functioning	Instantiation (Assessment tool)
Form of Assessment	Questionnaire	Matrix / Scoreboard
Maturity definition	Process-focused	
Practicality	Specific improvement activities	Specific improvement activities and deliverables

Table 30.: General preferences of Company A

The AMM is the model that best fits these requirements. The KPAs and questions are derived from practice. The form and the functioning are described and it uses a simple questionnaire for the assessment. Furthermore, it is process oriented and defines special improvement activities. In addition, due to the defined questions it is a suitable basis for the interview. For the interview an open interview guideline was chosen as method, in order to deal with spontaneous reactions and emerging questions. The interview was personally conducted at the industry partner company and it was digitally recorded.

5.3. Interview guideline

The interview guideline has been created to provide a controlled direction for the interview. However, care was taken to include spontaneously occurring subjects, ad-hoc questions, emerging issues, and more precise and individual experiences of the expert. In particular information on maturity models, which have been formerly applied should be included. The interview guideline is divided into two parts.

The first part has the aim to retrace the development of the EA management approach. Questions concerning the first part are about the origin of the EA management, the change of the situation after takeovers and acquisitions, including new challenges, the perception of future, and relations to the aforementioned process documentation. The whole interview guideline is attached in Chapter A.

The objective of the second part is related to the assessment of the current state of EA management. The questions in this part relate strongly to the questions from the AMM. They have been partly merged and combined to an open questionnaire, instead of simple yes/no questions. This form differs from the original form of the assessment, but allows to consider additional and important aspects in the EA management of company A, which are not captured by the model.

5.4. EA management perspective and development

The interview partner is below labeled as *Expert A* and he is working an IT portfolio manger. He was in the enterprise architecture team until one year ago.

The history of EA management approaches dates back to single projects concerning the integration of an enterprise-wide data model of Company B, in 1998. At this point repositories were established to manage application systems centrally and a common process model for project management was established, which defined the deliverables of the application systems to be developed. The responsibilities were distributed across different organizational units, because a central unit, which is responsible for architecture was not established.

Four years later, an first EA framework was developed within a project, which is valid even after the merge of Company A and Company B and still used throughout the group. Furthermore, another essential part of the project was the restructuring of the entire application landscape to reduce IT costs. The project was followed by an organizational restructuring of the IT subsidiary according to the newly defined structures, which were derived from the enterprise's business model. Thus, the EA program and the EA management process has it's origin at Company B. The development of the EA management at Company B is summarized in Figure 21

The challenge after the merge of IT was at first to get an understanding of the differ-

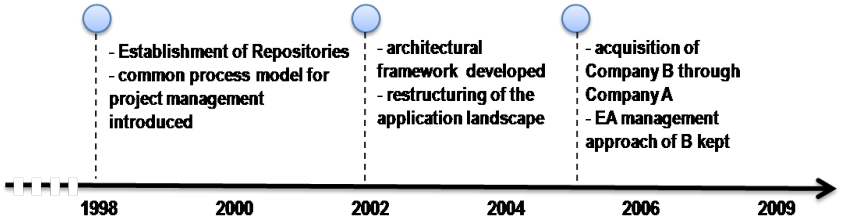

Figure 21.: Milestones in the development of EA management at Company B

ent development of EA and EA management in the different countries and as a second to reach a common understanding of these subjects. Nevertheless, the development of a common understanding will still take a long time.

So far no EA management maturity model was used, but the problem of the maturity model appliance are known. Company B had used *Software Process Improvement and Capability Determination* (SPICE)[3] to determine maturity levels in software engineering and therefore they also established an audit process. Today, there are also aspirations to use maturity models in EA management.

[3]http://www.sqi.gu.edu.au/spice/

5.5. The Assessment

This section contains the application of the maturity model at company A. The section starts with an introduction to the former EA management documentation. Subsequently the EA management approach is evaluated on the basis of this process documentation. The section ends with the assessment of the current EA management approach.

5.5.1. EA management documentations

The EA management documentation was created by Company B and it was adopted with the launch of the EA management program in 2002. It was also used in this form by Company B and it has been approved by Company B's steering committee. The documentation is outlined in the following, to identify the questions of the AMM that can be answered on this foundation.
The underlying goal of the presented EA management approach was the incorporation and implementation of target architectures of the corporate group. One focus was the inter-coordinated development to reach in the target architectures. For that purpose guidelines for cooperation and architectural work were set up: . Furthermore, single activities were described and associated with tasks and roles.
The guidelines for cooperation provide principles for the communication of changes in guidelines, standards, and specifications in general. These principles imply the development, the approval, and the appraisal of these guidelines. For instance, there is a close collaboration between the architecture division, the software engineering division, the system operations, as well as the executive board within the creation of these guidelines and standards. Afterwards, the guidelines were approved in order by their importance by different bodies of the enterprise.
The documentation shows two individual processes within the EA management. The first contains the creation and update of architectural standards for the application architecture, as well as the development of a master plan for the future use of IT at Company B. This activity is distinguished between a functional, a technical, and a security perspective on the development of standards. All these three perspectives imply a controlled improvement and development of the architecture with regard to the cost-benefit ratio. The second is the creation and update of the general IT strategy. All these activities are in the responsibility of the architecture team. The activities have a clearly defined goal and describe a number of tasks that are part of the process. In addition, the initiators of the activity are mentioned, the auditors and the receivers for the results are defined by them. The involved roles are not documented in detail. Their responsibilities can only be implicitly derived from the activities. Often, there are more than one role involved, so the responsibilities are not clearly presented in this documentation.
The documentation defines only two main activities of EA management. The major part of the documentation is the definition of guidelines and specifications, which define what have to be done at a high degree of abstraction. It is assumed that the documentation is incomplete and does not show the entire state of EA management. Therefore, few rules for the assessment have to be made.

- Those questions are answered with "yes", which are clearly visible in the documentation.

- Those questions are answered with "yes", which are implied reliable in the documentation.
- All other questions are not answered. Because, it can not be identified if the answers are missing or not fulfilled.

This means that the assessment of the process definition can not be completely evaluated. However, the answered question items are the basis to trace the development of some KPAs.

5.5.2. Evaluation results of former process definitions

This section shows the assessment of the EA management approach of the documentation. Step by step, the documentation is examined with regard to the questions of the AMM. For each of these KPAs the status of the EA management approach is summarized. Due to the small extend of the documentation, it is not possible to answer all questions. A summary

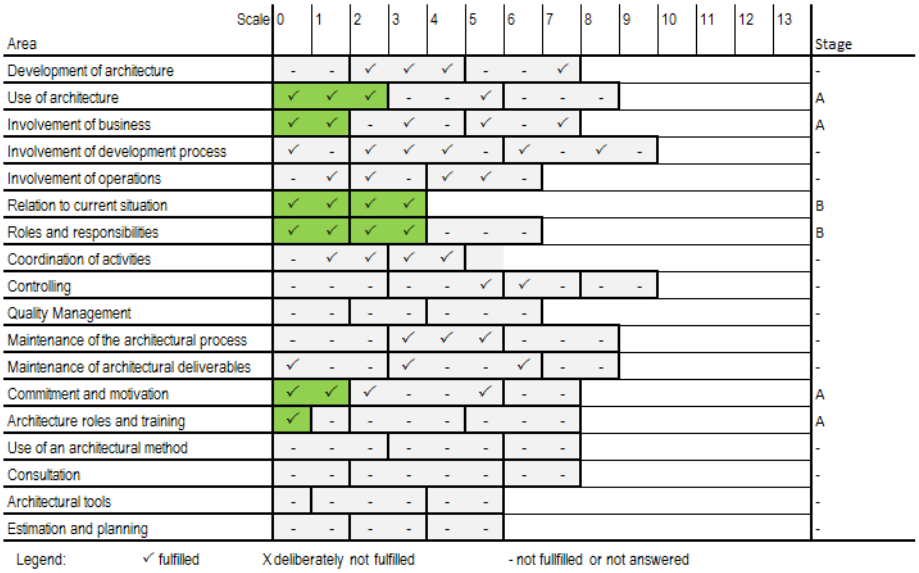

Figure 22.: The Architecture Maturity Matrix of Beta based on Process Documentation

of the answered questions concerning the process documentation are shown in Figure 22. The assessment of each KPA is detailed below.

1. **Defining Architecture**
   The EA management approach described in the documentation is an continuous process. The needs for action are periodically identified and integrated within the architectural development. Furthermore, the architecture specifications for projects are continuously updated and improved on the basis of experiences made with former projects. The actual state of EA is continually reviewed and improved if necessary. The improvements results of informal feedback triggered by the overall workforce. The EA is kept up to date, as the guidelines for EA development, the standards for

the EA, as well as the plans for the future use of IT within the enterprise are annually updated and adjusted.
The enterprise has also implemented a release process. So the COO[4]-board in collaboration with the architecture-board plans, defines, and leads explicit architecture releases, which represent the target architecture. The changes respectively the newly created architecture products are published to the stakeholders.
Beside the architects there are other parties involved in the development of architecture guidelines. These guidelines define the framework for architecture development, and thus the architecture results itself. The guidelines are developed in cooperation with the executive management, system developers, and system operation. Furthermore, there are different roles and bodies involved in the approval of deliverables and architectural products.

2. **Use of Architecture**
The EA projects got explicit and formal approval by management. The guidelines and specification concerning the business process architecture were approved by the COO-board and by the management of the affected business devision. In addition, the IT architecture is similarly reviewed by management.
The architecture provides also a picture of the organizational goals, because the basic objective is the implementation of target architectures of the enterprise's business division and IT.
The EA is not accessible for all employees. The architecture developments are only published to the stakeholders. This implies employees of the respective business divisions and the involved external partners. Furthermore, it is no access (pull) described within the documentation but rather an active communication (push) of the architecture developments. The EA provides explicit guidelines, which can be applied by projects. These guidelines were already mentioned above.

3. **Involvement of Business**
The Involvement of business is still on a basic level. The EA management provides a clear relationship between the EA and the business goals, because the balance between short-term realization of business functionality and improvement of the architecture is ensured through guidelines. The EA development is also driven by specific business goals, but an assessment of these goals was not established. The business divisions were also regularly participating in the EA management and EA discussions and therefore they have influenced the development of architecture guidelines too. The architecture is seen as a strategic factor of success. This is especially reflected in the organizational structure, e.g. there was a special architecture board established and the management approved the EA projects.

4. **Involvement of development process**
The involvement of the development process is on a structural level. There are explicit specifications for EA projects and the experiences made within these projects were incorporated in the architecture specifications for EA projects. Thus, these projects have to comply with guidelines and EA standards. There are no exceptions defined. The project method is default for each project and no exceptions were

[4]COO stands for chief operating officer

defined concerning the use of this method. The developers are participating in defining guidelines for the EA management and they give feedback on the basis of their experiences made with applications and EA projects. Thus, it was secured that the EA management approach is also useful for the EA projects and the definition of guidelines.

5. **Involvement of operations**
   The system operation workforce was also closely participating in the development of EA management guidelines. Thus, it is implied that system maintenance and management is given appropriate attention when developing the EA and there is regular feedback for the EA management. It can not be identified whether the system operation division also includes EA management guidelines in their daily operations.

6. **Relation to current situation**
   The EA management approach defines the relationship between current and target EA. All documented activities refer to the analysis of the current EA and the development to the target EA. The documentation also provides guidelines for the migration from the current EA to the target EA. Additionally, IT roadmaps, which build the foundation for the releases and the migration have to be created and updated. Furthermore, the planned actions have to be described.

7. **Roles and responsibilities**
   The organizational structure is not explicitly described within the documentation. However, it is defined that the decisions about the EA projects and the changes of EA management approach have to be approved by management, e.g. through the COO-Board or the executive management of the IT division. Thus, it is implied that EA management was a part of the management responsibility. Furthermore, the responsibilities of each activity were clearly assigned within the organization, because the initiators, the auditors, and stakeholders are defined. The release and publishing process has granted that the EA management had an official status within the organization.

8. **Coordination of activities**
   The EA management was also used to coordinate EA projects coordinates the projects. The development of the EA was carried along the different business divisions. Additionally, the EA management provides cross-oriented promotion to use the same know-how, a common infrastructure, and the systematic use of new technologies. Thus, the coordination is on a very high level in the AMM.

9. **Controlling**
   The documentation defines no activities concerning this KPA.

10. **Quality Management**
    The documentation includes two quality norms for the selection of EA management rules and the priorization of EA projects. These norms are formulated in relation to cost-benefit ratio and the risk of an technology over the life cycle. These norms were incorporated during the planning, but it is not described if these values are later

checked. Thus, the quality management in relation to the questions of the AMM is completely absent.

11. **Maintenance architecture process**
The creation of the EA management documentation was also the start of the official EA management at Company B. Thus, the EA management approach was not assessed at this point, but there was already a maintenance procedure in place. This procedure defines that the guidelines of EA management were continuously developed by architects in cooperation with stakeholders and afterwards approved by management in order to their importance. The occurring changes were communicated to the relevant stakeholders.

12. **Maintenance architecture deliverables**
The maintenance of EA deliverables is also defined within the documentation. Their maintenance was based on the analysis results concerning the current EA and EA management approach. The occurring changes were communicated to relevant stakeholders.

13. **Commitment and motivation**
The structural organization of the enterprise architecture unit has shown that the EA management was seen as important by management. There was time and money allocated to establish the described EA management process including the different activities, as well as an Architecture-Board. It was also actively promoted that compliance to the EA is important for projects. Therefore, guidelines were defined concerning the project management. It can be concluded that compliance with the EA became one quality aspect of IT projects.

14. **Architecture roles and training**
The role of an enterprise architect exist within the organization. This is implied by the existence of an Architecture board. Other questions of this KPA can not be answered on the basis of the EA management documentation.

15. **Use of architecture method**
The organization had established an generic EA management method. This method was used for the derivation of the EA from the business model of the enterprise. The other questions of this KPA can not be answered.

16. **Consultation**
The consultation is an important point within the documentation. Principles were defined concerning the cooperation in general, and especially to the close collaboration of architects with system developers and system operators within the EA management and EA development. The documentation does not mention that there are descriptions about agreements made within meetings. This is probably more a part of general rules concerning the communication processes of Company B.

17. **Architecture tools**
The documentation did not describe the use of architecture tools. Thus it is classified as absent.

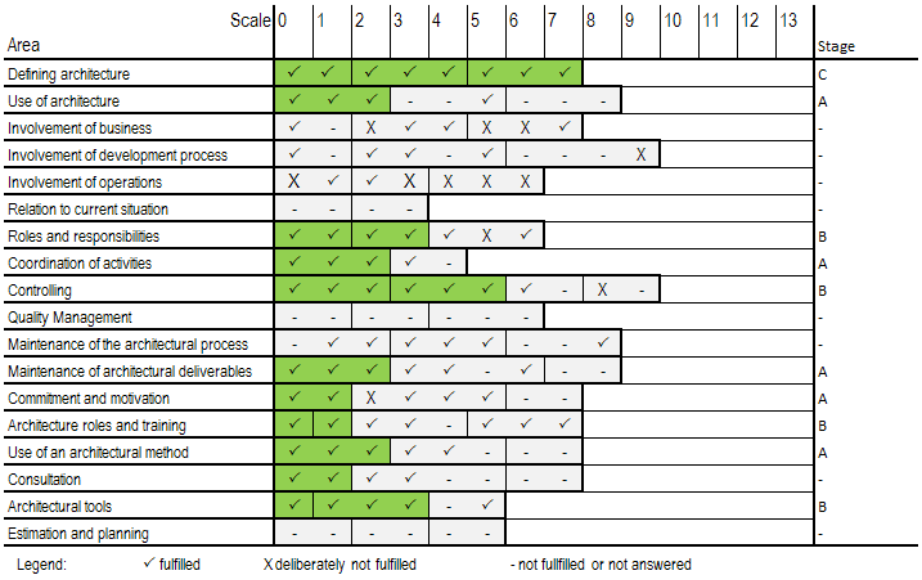

Figure 23.: Architecture Maturity Matrix based on Interview

18. **Estimation and planning**
    There is not estimation and planning method mentioned in the documentation.

5.5.3. Interview as current state of EA management

The main objective of the interview was to get a picture of the current EA management approach at Company A. The interview consisted of open questions as mentioned before. The interviewee is as noted before, not familiar with all developments in EA management in detail, but he still has an overview of the EA managementapproach.

Evaluation of the current EA management approach at the financial service provider

A overall picture of maturity level of the current EA management approach is given in Figure 23. The characteristics of EA management in relation to the KPAs is given below.

1. **Defining Architecture**
   Company A has a separate organizational unit for EA management, which ensures a continuous EA and EA management development. The EA development itself takes place over many projects in which future software and infrastructure architectures are developed. These projects start with an concern of the business or IT. A standard method is used for the implementation of the EA projects, but before they have to be approved by the IT boards, in which the enterprise architects are the major part. Thus, it is secured that different stakeholders are involved in the EA development. In the case of new developed EA parts, pilot projects were established and launched. These help to identify impacts and users for these developments.

2. **Use of Architecture**
   The development of the EA is based on the three-years plan, which is created by

the business. Thus, the EA provide a clear picture for the organization's goals. The developments are also approved, because reviews are included within the development processes and the responsibilities for reviews of EA management and EA developments are assigned to the executive management of the IT.
The EA management is accessible for all employees. Due to the derivation of the EA from the enterprise business model company A had established an process portal, which is also accessible at business site. It is important for the business divisions to have all relevant informations, also concerning the EA management. Additionally it was mentioned that the guidelines for EA management are no secrets and the knowledge of these guidelines is a necessity for the different developments of the EA.

3. **Involvement of Business**
   At this point, there appeared many changes through the acquisition by Company A in comparison to the former process definition. Today, the business side provides only demands and the implementation is entire the responsibility of the IT. The interface between architecture and IT is the three-year plan. This interface should establish a supplier-customer relationship between business and IT, but there are also Business Relationship managers, who are in contact with the business side. The responsibilities should be clearly separated and this departs from the idea of a very close collaboration. Summing up, the EA management has still a relation to the business goals through the three-year plan but there are no discussions wanted within the EA management or EA projects.

4. **Involvement of development process**
   The compliance to the EA is a integral part of the project methodology. There is a international and standardized process for the implementation of IT projects and at a size with more than 50.000 Euros each project have to grant compliance to the EA. The EA management provides guidelines and cookbooks, which specify and constrain the area of action for the developer. They also provide specifications, which technology and programing languages have to be used. The feedback for the EA management is an informal process. The approach is reviewed by selected employees, who have to work within these processes. This feedback leads to changes, which are integrated into the normal release processes. Company A sees the employees, who have to work with these processes as customers and their needs have to be satisfied. Further, the development of EA is seen as an interdisciplinary activity and therefore all core processes are coupled to EA management.

5. **Involvement of operations**
   Company A manage the involvement of operations through the budget issue. Within the budget it is clearly defined what the administrators are allowed to do. This are especially small pro-active changes to the systems, e.g. patches or bug fixes. There are no changes allowed, which influence the EA. Thus the system operation does not incorporate guidelines from architecture.

6. **Relation to current situation**
   It was mentioned that the current situation or version of the EA management is not

analyzed.

7. **Roles and responsibilities**
   The responsibilities for EA development and EA management are assigned at management level. The EA management process has defined clear responsibilities and it is arranged at the highest level, the same as governance and business management have. The responsibilities for different activities are defined through a framework, which determines for each activity a clear responsibility. This framework is very flexible regarding the future integration of roles and responsibilities. The current version of the EA management is published through the release management.

8. **Coordination of activities**
   The coordination of activities is an essential part of Company A's EA management. The EA management is used to show dependencies between the IT projects and to manage and avoid conflicts between the IT projects. Due to the amount of information, the dependencies are identified on a high level. The dependencies within the projects and within the different divisions structures are covered by standard guidelines.

9. **Controlling**
   The controlling process concerning projects is not established within the EA management. Company A is collection information to steer the development but these are not used for an measurement.
   There are guidelines in place, which define the area of action for system developers and of course the project mangers have to bear consequences if they don comply to these guidelines, e.g. they use another programing language then the specified one. Depending on the size of the project there were also provided additional architects who are advising the project concerning the compliance to the architecture.

10. **Quality Management**
    The quality of the architecture process is not assessed in any form and it is not considered whether an IT project has achieved the planned changes. This is seen a future goal of the EA management at Company A, but it is also seen as a top activity. It was mentioned that all other activities have to be well defined to get valid results and thus it was not started yet.

11. **Maintenance architecture process**
    The EAM approach is currently not documented, because the underlying framework is replaced to an international EA management process framework. Thus, there are no informations available according the future maintenance process for EA management. In general there is a process team, which is responsible for the maintenance of internal IT processes and project management.

12. **Maintenance architecture deliverables**
    The EA deliverables are updated along with the systems. Thus, there are releases on the different applications, which are presented on a map with different colors. The changes to the deliverables and the systems are communicated through regular publications, e.g. on a portal.

13. **Commitment and motivation**
    EA management is seen as important by management. This is indicated through the organizational structure, so the EA department is located at the highest level within the organization The EA management of Company A has also an integrated change management, because every IT project have to refer to the architecture and thus indicates that compliance to architecture is seen as a major quality aspect. There is also a continuous EA management improvement, but this is an informal process and it is not known if this process is also accepted and supported by management.

14. **Architecture roles and training**
    The role of an architect is broadly assigned with an carrier path within the organization and the requirements at the architects are clearly defined. There is also a portal for the exchange of information about the EA, but not about best practices. The role of an enterprise architect is also a part of the framework for responsibilities, which was mentioned before.

15. **Use of architecture method**
    Company A uses a self-developed, generic EA management model. This model is used within a standard method for the development of the EA. It is continuously developed by an informal feedback process. The changes or new demands were derived from arising questions during the operation. All the changes of the information model are entirely developed bottom-up. The main objective of the informal feedback process is the acceptance by the users of this method. The methods collects only such information, which is required for the EA management.

16. **Consultation**
    Consultation takes place via virtual architecture teams. These are aligned to the processes and get early in contact with the EA projects. The decisions taken during this phase will be logged within a protocol, which also includes future actions of the project. There is continuously contact to the project manager through the virtual architecture team.

17. **Architecture tools**
    There are different tools in use to support the entire EA management process. A variety of tools from the different areas are used to collect the needed information for EA management. An integrated tool does not exist, but the information and the various EA artifacts are kept consistent by the use of repositories. Statements about management of the tools were not given, but a tool management is implicitly defined. An examples for a tools, which is used is ARIS[5].

18. **Estimation and planning**
    There are no estimations for the future development of the EA made. The planning of the EA development is made through the annual planning of EA projects. They are defined on the basis of the three-year plan made at the business side.

[5] http://www.ids-scheer.de

5.6. Comparing the evaluation results

The chosen approach of an assessment through an open interview has unfortunately some of limitations. It was only one interviewee available at the site of the industrial partner, who had a good overview of the EA management approach, but was not familiar with all the details. In addition, the interview was limited in time and the complex assessment contains many questions, so that not all questions of the AMM could be answered in detail. This can lead to misjudgments in some areas of maturity model, but in general the impact on the results should not affect the evaluation of the classification framework.

The results clearly show that the EA management approach of the industrial partner could be assessed by the model. Furthermore, the AMM was able to trace the development of EA management in both directions. At the one hand improvements have been achieved in the KPA *Defining architecture* and at the other hand in the KPA *Relation to current situation* an decrease in the maturity level was determined. The rules defined by the AMM define that the industry partner is still on the lowest level of maturity, because the current situation was not incorporated in the EA management, as well as the involvement of business is on the lowest level. The AMM provides concrete recommendations for the improvement of the EA management approach. The enterprise should focus on the improvement of the less developed KPAs, e.g. *Estimation and planning* or *Involvement of business*. The results show that the classification framework supports the selection of a suitable maturity model, that meets the requirements of the enterprise.

However, there are also some restrictions of the model and its scope. With regard to the information gained from the EA management documentation it was identified that the aspect of IT security plays a role in in the approach of Company B but was not assessed by the AMM. The sustainable alignment of IT with the business and the support of the business processes were already presented in this thesis as a major scope of the enterprise-level management processes assessed in the AMM [St05]. There are also contradictions with regard to the involvement of the business within the AMM. Company A tries to establish a loose coupling between the business and the IT. There is a clear interface defined through the three-years plan and therefore the business should not be involved in architecture discussions. Thus, the enterprise could never reach a high level within this KPA defines by the AMM, because this recommends this direct discussions.

The AMM also defines that all KPAs should be equally developed. This means, that the not developed KPA *Quality management* of the industrial partner should be focused in the future for an improvement of the EA management. This is in contradiction to the statements of the interviewee, because it was mentioned that the *Quality Management* is a future objective, but all the other processes should be well developed before. It is assumed that the *Quality Management* can only deliver good results if the right information is considered at the right time. Thus, this KPA is seen as a "on top" process which should be developed at last. This perception is the opposite of the model's rules.

All in all the maturity model has a similar focus as Company A has. Thus, the communication principles are mapped by the model, which are also seen as important by Company A. Additionally, the system development and the system administration are included in the AMM, which is also defined by company A.

6. Recapitulation and prospects

This section contains a short summary of the results obtained in this thesis and gives an outlook on future work in the area of maturity models for EA management.

6.1. Recapitulation

The first Section presented the topic of EA management and maturity models to the reader. The basic terms were defined and the advantages for the use of maturity models were discussed. The second Section outlines the history and development of maturity models in EA management. The backgrounds of the identified maturity models were described. They were classified according to their origin and their structure was briefly analyzed. Finally, a number of maturity models was selected for the subsequent classification.

The third Section details on the development of the classification framework. This framework was developed on a theoretical background through the reuse and adaptation of criteria from related approaches on maturity models. Furthermore, additional criteria were identified, especially regarding the scope of the EA management maturity models. The classification framework distinguishes three types of criteria – *general aspects*, *structural aspects*, and *aspects with regard to the scope*. The criterium concerning the scope of the maturity model was derived from the used EA management definition and general characteristics of processes.

The fourth Section describes the application of the previously developed classification framework to selected EA management maturity models. The obtained results have revealed significant differences especially concerning the scope of the maturity models.

Finally, a model was selected based on the results of the analysis and classification framework. This model was applied at an industrial partner. It was an old process documentation available for the assessment of the former state of the EA management, as well as an interviewee for the assessment of the current EA management approach. These assessments are used to identify, if the analysis and classification framework supports the selection of a suitable maturity model.

6.2. Prospects

The thesis can be considered as starting point of analyzing and classifying EA management maturity models. In this thesis a number of free-available maturity models were reviewed and one was applied at an industrial partner. Future work should incorporate also charged maturity models and also industrial partners concerning the application of

the maturity models. The results could lead to an extended evaluation framework for maturity models, which takes the aspects of certain branches, organizational structures, as well as specific goals of the enterprise into account.

Furthermore, the application of the maturity model was artificial. Future work should also incorporate reviews of more natural assessments, i.e. through the observation of self-assessments, or third party assessments. These assessments provide further perspective on the application and may elicit new requirements for maturity models. Especially for an self-assessment a common terminology is of vital importance within the documentation, as well as an common understanding of involved roles and bodies.

Finally, future work may also motivate adaptations to the structure and the scope of the EA management maturity models. As mentioned before there are different approaches in which order an enterprise or an agency should develop its EA management. The results can help to develop more suitable and flexible EA management approaches.

A. Interview guideline

The interview was conducted in German, because the interviewee is a German native speaker.

1. Allgemeine Entwicklung des EAM
   a) Erläutern sie bitte kurz ihren Werdegang?
   b) Was verstehen sie unter EA bzw. unter EAM (wenige Worte)?
   c) Seit wann haben sie eine fördern sie Aktiv EAM?
   d) Welchen Herausforderungen bzgl. EAM sahen, sie sich bei der Übernahme 2005 durch die Unicredit? Und wie war die Unicredit bzgl. des EAM aufgestellt?
   e) Wie hat sich die Situation seit dem Entwickelt? Wie ist die derzeitige Sicht des Managements auf das EAM (strategisch wichtig)?
   f) Wie sehen sie die zukünftige Rolle des EAM in ihrem Unternehmen bzgl. der Strategie ihres Unternehmens am Markt (Akquise)?
   g) Wurde bereits ein Assessment mit Hilfe eines Reifegradmodells durchgeführt? Wenn Ja, wie war es motiviert?

2. Fragen für das Assessment
   a) Wie wird das EAM bei ihnen im Unternehmen durchgeführt bzw. gesehen, als einzelne Projekte, oder als kontinuierlicher Prozess? Und was wird als zwingend gesehen beim Start eines neuen Architekturprojektes (Produkt) ?
      - Wird ein Planungsansatz erstellt und erfolgt die Entwicklung erst nach Anweisung?
      - Gibt es einen Releaseprozess um die Architektur kontinuierlich aktuell zuhalten
      - Werden Vor der Erstellung eines neuen Teils der Architektur die User und der Gebrauch bzw. Nutzen definiert ?
   b) Wie wird die EA in ihrem Unternehmen wahrgenommen bzw. für welche anderen organisatorischen Prozesse wird sie genutzt? Beispielsweise: Als Tool bzw. Rahmenwerk für die Ziele der Organisation? Innerhalb der Entscheidungsprozess der Organisation? Als pro-aktive Maßnahme für Projekte inklusive Richtlinien und Motivation ?
      - Erteilt das Management die Freigabe für die EA?
      - Ist die EA für alle Arbeitnehmer einsehbar?
      - Wird sie in organisatorischen Planungs-, Entscheidungs-, Kontroll- Prozessen genutzt? Wird es für die klare Koordination der Fach- und IT-Entwicklungen genutzt ?

- Ist für jedes Projekt klar definiert, welchen Teil der EA es beeinflusst, bzw. welche Auswirkungen es hat?

c) Welche Unternehmensbereiche und Parteien neben den Architekten sind maßgeblich involviert, d.h. wichtig für den Erfolg des EAM in ihrem Unternehmen und warum sind diese strategisch wichtig?

d) Wird die Architektur in ihrem Unternehmen gelebt? Sehen die Meisten sie als wichtig an?

e) Wie erfolgt die Kommunikation bzw. Zusammenarbeit innerhalb der *EA Abteilung*?

f) Wie erfolgt die Kommunikation zwischen den Abteilungen (informell? Meetings?)? Welche Abteilungen werden in die Kommunikationsprozesse einbezogen? Welche Regelungen müssen dokumentiert werden?

- Gibt es regelmäßige Teammeetings und werden die Vereinbarungen dokumentiert?
- Gibt es regelmäßige Treffen mit den Projektbeauftragten? Werden die die Anweisungen zu EA Projekten (Ziele, Resultate, Terminologie) dokumentiert?
- Gibt es regelmäßige Meetings zwischen Architekten und Entwicklern, und werden die Vereinbarungen dokumentiert?
- Gibt es regelmäßige Treffen mit Benutzern, Beauftragten zum Feedback über die EAM (Entwicklungsprozesse und Methoden)? (Dokumentation)
- Gibt es von anderer Seite Entwicklern, Admins Feedback zum Prozess?
- Gibt es Feedback von der Organisation?

g) Wie ist die Fachseite in die EAM Teilprozesse eingebunden? Ist sie der *EA Abteilung* gegenüber verpflichtend eingebunden? Erfolgt die Einbindung auch in die andere richtung?

- Gibt es eine klare Beziehung zwischen Architektur und Zielen der Fachseite?
- Wird die EA gegen deren Erfüllung gemessen?
- Klare Terminologie auf beiden Seiten?
- Entwicklung der EA getrieben von klaren Zeilen der Fachseite (für jedes Projekt zurechenbar)?
- Gibt es regelmäßige Teilnahme der Fachseite an Architekturmeetings?

h) Wie sind die Systementwickler in das EAM integriert? Welche Rolle spielt das EAM in Bezug auf den Entwicklungsprozess? Beispiel Motivator oder Richtlinie

- Beziehen sich Projekte auf den Entwicklungsprozess?
- Sind Standards Teil des Entwicklungsprozesses? Beinhalten diese Standards auch den Blick auf die Architektur (Compliance)?
- Wird auch von der EA-Seite Rücksicht auf den Entwicklungsprozess genommen?

- Helfen die EA Architekten bei der Ableitung von EA Zielen in Design Ziele?
- Gibt es n kontrollierten Prozess für Entwicklung hinsichtlich gewollter Abweichungen von der EA?
- Wie wird die EA verpflichtend in die Systementwicklungsprozesse eingebunden bzw. Motiviert?
- Wird es durch das IT Management und Management allgemein gefördert?
- Wird die EA als Qualitätsaspekt gesehen?
- Wird die EA in Projektplänen berücksichtigt?

i) Wird die EA dazu benutzt Projekte zu koordinieren? Sowohl untereinander als auch innerhalb? Wenn ja, was sehen Sie als Vorteile?
   - Wird die EA für Design Entscheidungen genutzt und dazu Neuentwicklungen von bestehenden Dingen zu vermeiden?
   - Wird EA für die Entwicklungskoordination zwischen Projekten aktiv genutzt?

j) Werden Projekte gegen die EA gemessen, also ob sie die Ziele bzw Vorgabe erfüllen? Wenn ja, wie? Welche Auswirkung hat so ein Messergebnis? Welche Maßnahmen werden ergriffen um (vorab) Abweichungen von den EA Vorgaben zu vermeiden? Oder ist es bereits selbstverständlich?
   - Misst das Projekt Reporting *EA Compliance*?
   - Sind Konsequenzen für den Projektmanager klar definiert?
   - Gibt es Instrumente um die Compliance zu sichern?
   - Nehmen EA Architekten in der Startphase des Projekts Teil?
   - Ist Compliance bereits Teil der Projektdefinition?

k) Wie beziehen die System-Administratoren (Hardware, Software) die EArchitektur in Betracht? Gilt dies auch umgekehrt?
   - Wird die Systemwartung im EAM berücksichtigt?
   - Berücksichtigt die Wartung EAM (Compliance) ?
   - Nehmen die Administratoren auch in der Entwicklung der Architektur bzw. EAM teil? Gibt es Richtlinien außerhalb dieser Entwicklungen?

l) Wird auch beim EAM immer der derzeitige Stand des EAM bzw. der EA berücksichtigt? Wenn ja, wie?
   - Gibt es eine Policy (Grundsatz, Rahmenvertrag) bezüglich der derzeitigen Situation?
   - Wird sie hinsichtlich der zukünftigen Entwicklung berücksichtigt?
   - Gibt es Richtlinien für die Migration? (Evtl. entstanden aus der derzeitigen Situation)

m) Wie und auf welcher Ebene sind die Verantwortlichkeiten für die einzelnen EA Dokumente/Teile geregelt? Gibt es einen offiziellen Status für die Teile?
   - Sind die Verantwortlichkeiten klar geregelt?

- Gibt es einen Verantwortlichen für jeden Prozess?
- Auch das Management der Fachseite verantwortlich?
- Sind sie auch für den Beitrag der EA zum Business verantwortlich?

n) Welche Aufgaben hat der EA Architekt in ihrer Organisation und Wie werden die Architekten von der Organisation Unterstützt? (Trainings, Tools etc.)?
   - Sind die Aufgaben klar geregelt und festgeschrieben?
   - Gibt es Tools und Methoden extra für Architekten, die die Entwicklung und den Austausch von *best practices* fördern?
   - Gibt es Karrierepfad, Lernprozesse Zertifizierung?

o) Wie sieht das methodische Vorgehen für die EA Assignments aus? Welche Aspekte der Architektur beinhaltet das? Wird ein Planungsansatz für jedes EA Assignment erstellt und wird dem Ansatz wirklich gefolgt?
   - Verschiedenen Aspekte bekommen verschiedene Aufmerksamkeit?
   - Gibt es eine generische Architekturmethode? Wie wird diese immer benutzt?
   - Sind Abweichungen von dieser Methode dokumentiert und begründet?
   - Gibt es einen Feedbackprozess für die benutzte Methode?

p) Werden Werkzeuge/Software für die Arbeit mit der Architektur benutzt, wenn ja welche? Wie unterstützen die Werkzeuge die Prozesse?
   - Benutzen Architekten die selben Werkezeuge?
   - Ist die Verantwortlichkeit für das Management der Software/Tools klar geregelt?
   - Sind die Werkzeuge integriert? Und stellen sie die Konsistenz der einzelnen Dokumente (EA Produkte sicher?)

q) Beschreiben sie doch bitte die Planungs- und Vorhersagemethoden hinsichtlich der EA Projekterstellung? Wie werden die Prozesse verbessert?
   - Gibt es standardisierte Planungsmethoden?
   - Werden bei Ausführung der EA Assignments Abweichungen zum Plan dokumentiert und erklärt?
   - Gibt es einen Prozess für Feedback bzgl. Vorhersage und Planung?
   - Gibt es Statistiken über die Verwendung der Methoden?

r) Wie erfolgt die Pflege der EA Produkte? Ist dies ein regelmäßiger Prozess? Werden alte Inhalte entfernt? Wie werden Änderungen kommuniziert?
   - Gab es schon mal eine neue Version der EA?
   - Gibt es einen Change Management Prozess?
   - Ist der EArchitekt verantwortlich?
   - Gibt es Grundsätze in der Pflege? Wird zwischen den verschiedenen Artefakten unterschieden?

s) Ist der EAM Ansatz dokumentiert und wird er gepflegt? Wenn ja wie? Wie werden Änderungen kommuniziert? Ist der Prozess in der Organisation kommuniziert?

- Wurde er schon mal aktualisiert?
- Gibt es Unterstützung durch das Management?
- Ist die Verantwortung klar geregelt für den EAM Prozess?
- Gibt es einen regelmäßigen Pflegezyklus?
- Gibt es einen Verbesserungsprozess und führt der zu realen Veränderungen?

t) Wie wird die Qualität der EA bewertet? Und wie wird die Qualität des EAM Prozesses bewertet?

- Gibt es Metriken und Qualitätsanforderungen?
- Gibt es n Qualitätsprogramm?
- Ist die Qualität der EA Teil unternehmensweiter Qualitätsstandards?
- Wird es als Vorteil Empfunden unter der EArchitektur zu arbeiten?
- Sind auch die Beziehungen zu anderen Enterprise Level Prozessen Teil der Qualitätssicherung?

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