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Improving Integration Efficiency of Enterprise Architecture Management and IT Operations: A Qualitative Requirements Analysis

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***Abstract*—Both areas, Enterprise Architecture Management (EAM) and IT Operations (ITO), have the same objective to establish an alignment of business and IT. With EAM this is to be achieved by strategic optimisation of fundamental elements of an organisation on the basis of holistic, stakeholder specific architecture descriptions [1]. In contrast, in ITO all specific configurations of systems landscape, systems or system components are to be implemented in that way that they comply with functional or physical characteristics, previously defined in requirements documents [2]. So, both areas possess a functional relationship and are, therefore, interdependent. Within this context, it was of interest, how practitioners in EAM and ITO deal with these differences during planning and realisation of enterprise architecture (esp. IT architecture) and, at the same time, comply with this functional relationship.**

***Keywords*-System Landscape Engineering; IT Architecture Transition and Migration; Empirical Requirements Analysis; IT configuration; Information Management; Software Engineering**

I. Introduction

Whereas fundamental elements of an enterprise architecture are considered in an aggregated manner at Enterprise Architecture Management (EAM), IT Operations (ITO) models are focused on specific systems or system components and are, therefore, considered in detail. Figure 1 shows the interrelationship between IT system landscape, IT configuration and IT architecture.

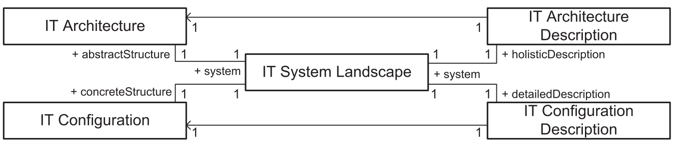

Fig. 1. Concept of IT system landscape, IT configuration, and IT architecture (UML class diagram)

According to IEEE[1] Std 1471–2000 a system has an *architecture* (*abstract structure*) that is described by a *holistic architecture description* [3]. On the other hand, according to ISO Std 10007:2003, a system also has a *configuration* (*concrete structure*) that is described by *detailed configuration descriptions* [2]. Assigned to an *IT system landscape* as a system, consisting of applications, system software, and IT infrastructure, it has an IT architecture and an IT configuration with corresponding descriptions.

In particular, it was enquired, how descriptions of the enterprise architecture's *IT architecture layer* [4] are implemented as IT configurations by ITO, today. Hence, three main questions for the analysis arisen:

1) What are the main experiences integrating Enterprise Architecture Management and IT Operations?
2) Which relevance do have models, modelling languages and tools for the documentation of Enterprise Architecture and IT Systems Landscape?
3) Which solutions are derivable for an improvement of the integration of Enterprise Architecture Management and IT Operations?

Requirements analysis is the activity to discover existing or new requirements, and to identify further requirements sources [5]. Requirements are understood as product or process characteristics or constraints that are necessary to solve a certain problem [6]. Different kinds of requirements exist: functional requirements, quality characteristics and general constraints [5]. The objective of qualitative research is to examine and interpret data to elicit meaning, gain understanding, and develop empirical knowledge. It is because of open and non–standardized techniques and procedures for gathering and analyzing empirical data that informational content can be captured completely [7]. So, qualitative methods to derive requirements for the integration of EAM and ITO seemed suitable. Hence, the chosen requirements analysis approach was separated into *data collection* and *data analysis*. First, for data collection, *expert interview* was the method of choice because the experts' points of view about integration of EAM and ITO was to be gathered. Other approaches were assumed not suitable due to the fact they would not produce valid results according to analysis questions [7]. Interviews were conducted guideline–based and semi–structured to achieve comparability of given answers [8]. Secondly, *data analysis* was based on a qualitative content analysis approach to systematically elicit conclusions from fixed, manifested communication content [9]. Other techniques for content analysis seemed not to be

[1]Even if not stated, all trademarks mentioned in this article are registered trademarks of the respective companies and organizations

valid according to analysis questions [7]. The analysis is, thus, oriented towards to extract statements from interviews to identify functional requirements, quality characteristics, and general constraints.

After a short overview about the used design of qualitative research approach in section II, the extracted interview results are to be presented in section III. Afterwards, in section IV, the derived requirements are to be shown. Criteria for evaluation are to be discussed in section V to show validity of research. This article ends with a conclusion and a short outlook in section VI.

II. Qualitative Research Approach

For expert interviews a guideline was used to establish comparability and to structure the talks [8]. The used guideline is organized in five topics (*A*–*E*). Each topic contains one or two central questions, asked to every interviewee and contingency questions, asked when convenient.

In topic *(A)* narratives about working and decision environment in EAM were to be gathered and documented to derive general constraints. The central question was: *Which relevance do Enterprise Architecture Management has to you and your organisation?* Additionally, for consultants, the second central question was: *Is there any dependency between company size and relevance of Enterprise Architecture Management?*

With topic *(B)* modalities of documenting enterprise architecture and IT systems landscape were asked. In particular, the role of modelling languages and tools were to be captured. The central question was: *How are Enterprise Architecture and current IT systems landscape documented?*

Frequency, triggers and possible causes for enterprise architecture changes were to be covered with topic *(C)*. The central question was: *How often is the enterprise architecture changed?*

Transition of enterprise architecture into IT configurations was addressed in topic *(D)*. In particular, coordination of EAM and ITO was of interest. The central question was: *How are enterprise architecture and changes transformed into IT configurations?*

The last topic *(E)* covered narratives and ideas about problems regarding integration of EAM and ITO. Additionally, experts were to be stimulated to talk about ideas of possible solutions. The central question was: *What are the main problems during integration of Enterprise Architecture Management and IT Operations?*

First contact to each interviewee was made via email, in which the analysis objectives and procedure were specified. Due to the fact the participants had strong time restrictions and because of their spatial distribution, talks were done via phone (approx. 20–35 min).

An expert is to be seen as a person, responsible for a specific function within an organisation and has, therefore, privileged access to specific information about certain areas of expertise. With this assumption, an expert is interviewed as one representative of a group, not as an individual [10].

TABLE I
Classification of Experts

Expert	***Characteristics***								
	Organisation			*Role*		*Scope*			*Ctry*
	Com	*Con*	*Gov*	*adv*	*acc*	*glo*	*reg*	*org*	*ISO*
E1	–	–	X	–	X	–	X	X	CH
E2	–	X	–	X	–	X	–	–	DE
E3	–	X	–	X	–	X	–	–	CH
E4	X	–	–	–	X	X	–	X	DE
E5	–	–	X	–	X	–	X	X	DE

Caption: *Com: Other Company; Con: Consulting Company; Gov: Government Agency; adv: advisory; acc: accountable; glo: global; reg: regional; org: organisational; Ctry: Country; ISO: 2–letter country code defined in ISO 3166–1 ALPHA–2; En: Expert n*

Many stakeholders are involved in the process of development and implementation of enterprise architecture and, hence, possible candidates to be interviewed [1]. To capture experiences and ideas from both sides, this survey was targeted on enterprise architects and IT operations experts. Here, it was assumed enterprise architects have, based on their holistic area of expertise, comprehensive knowledge regarding the field of study. In addition, it was assumed ITO experts also have comprehensive knowledge regarding transition of enterprise architecture into IT configurations. So, five experts with long–time working experience could be enlisted as participants (3 Enterprise Architects; 2 ITO Experts).

Participants (Table I) were isolated by types and, with it, analysed well–directed [11]. Particularly, the sampling was diversified by taking into account: *organisation type* (government agency, consulting, other company), and, therefore, *expert's role* (advisory, accountable) as well as *scope of expertise* (global, regional, organisational). Classification by type of organisation appeared advisable, insofar as a distinction between organisations using IT (e.g., government agency, other company) and organisations that advice other organisations on using IT (e.g., consulting company) is possible. Generalised knowledge about their customers was anticipated from consultants, which increases validity of the survey. Furthermore, it was assumed advisory enterprise architects have, because of their executive role, other experiences than enterprise architects that are essentially accountable for their organisations. Expert's knowledge can either be regionally restricted or globally valid as well as limited to a particular organisation or, respectively, valid across organisations. By having this diversification, as much experience was to be collected as possible. Despite of all different vocational and role–specific experiences with EAM and ITO, existing similar core interpretations should be identified and, if so, how similarities and differences are constituted.

Expert *E1* is an executive enterprise architect and member of Chief Information Officer staff within a Swiss government agency and accountable for many areas of responsibility. Expert *E2* and *E3* are advisory enterprise architects in two different international consulting firms with subsidiaries in

Germany (E2) or Switzerland (E3). In these positions, both advised many organisations in planning and implementation of enterprise architecture. In addition, Expert E2 is *Open Group* certified *Master Certified IT–Architect* and, hence, working in an executive position in customer projects. Expert E3 is head of the IT Transformation Management Division and, therefore, accountable for all enterprise architects in his organisation. Expert (*E4*) was accountable for the strategic planning of the hosting division in a German company until mid–2010, with more than 30,000 hosted servers. Expert *E5* is working in a data center for a German regional office and is accountable for coordinating databases, middleware, and technology. In these positions, Expert E4 and E5, were directly involved in the transition of enterprise architecture (esp. IT architecture) into IT configurations.

Interviews were captured by digital audio recording and transcripted. Here, simple transcription rules were applied because the objective of this survey was to derive interpretations from content and not from vocal utterance, filler words, or breaks [12].

III. Interview Results

A. Enterprise Architecture Management

Whereas experts 2, 3 and 5 consider EAM fundamentally important, for expert 1, in contrast, importance of EAM is limited to gain cost savings during use of IT. Due to the fact each department in his government agency is responsible for its required applications and has its own IT budget, the expert do not have a position of power in his role as enterprise architect. Regulations and instructions exist, which instruct a position of power, but, however, are useless in this context. Expert 4 pointed out EAM is especially important for translation of business processes into IT systems because of the absence of knowledge about construction of IT systems in business areas. Only by use of EAM, planning of a reference architecture is possible (E2). A reference architecture constitutes a functional structure of architecture elements, which are independent from specific products and, thereby, affects realization of aligned, functional building blocks and elements of IT infrastructure [13] [14] [4]. Furthermore, EAM is seen as a planning discipline to consolidate IT systems, IT organisations, and locations (E3). For expert 5, EAM is also used to plan construction of data centers. In his organisation, parts of current data center architecture are historically grown without EAM. Thereby, he regards enterprise architecture from IT architecture viewpoint, which is only a part of an enterprise architecture [4]. In this context, expert 4 stated in his organisation less than 10 per cent of IT systems are actually used for business operation only (others are demo, training, or development), and, therefore, EAM controlled. Objectives of EAM, named by experts, are:

- mediation between business areas and ITO,
- translation from business to IT requirements,
- creation of transparency and comparability of architecture elements and relationships,
- creation of mutual understanding of enterprise architecture in IT projects, and
- holistic view and control of architecture elements.

The importance of the last two points are increased, when expert 2 says, understanding an enterprise architecture always leads to right solutions. It must, therefore, be open and extensible.

Advisory enterprise architects stated, importance of EAM is independent from company size. But, the bigger the company size, the bigger its complexity and, therefore, the greater the benefit. This means the scope of EAM is, indeed, dependent from company size.

This is also evident in different statements, given by experts, about EAM tasks and instruments. For expert 1 only minimum implementation of architecture development exists: exertion of influence during IT projects, determination of reference architecture and required IT infrastructure based on costs, and interface management regarding to data and services. Additionally, he stated target architectures cannot be planned because a determination of a target architecture leads to a limitation of his room for manoeuvre due to his lacking position of power. But when he would do it anyway, business areas would define exceptions, which are not controllable anymore. In the other cases planning a target architecture is a core task of EAM. A target architecture is to be seen as a description of future states of one enterprise architecture. In the EAM context, many target architectures could exist to successively implement a final state (reference architecture) [4]. It is used as a foundation for: (1) assessment of architecture scenarios based on business relevance, (2) transition into IT infrastructure requirements, and (3) implementation. Further EAM tasks are: coordination of enterprise strategy and architecture, collect and assign business processes to IT systems, creation of target organisations, log and assess decisions taken, and as–is analysis of architecture based on costs/benefits. Using an enterprise architecture board is an essential instrument (E1–E3). It makes the position of an enterprise architect easier through establishment of transparency, determination of responsibilities, and enabling communication of board members. An enterprise architecture board makes decisions about solutions and checks results of IT projects. In addition, another instrument is the use of determined standardized (e.g., TOGAF) or individual (e.g., company defined) methods. Based on decisions taken, determination of realisation order of IT projects (portfolio management) is another instrument. Additionally, experts from ITO gave statements iterative talks with stakeholders are important. Typical decisions are: determination of standards and protocols, reuse of existing IT components in other business areas, insourcing/outsourcing, assignment of business processes and IT systems, and determination of architecture elements.

B. Documentation of Enterprise Architecture and IT System Landscape

In each case, the main reason to document enterprise architecture and IT systems landscape is to create and sustain transparency. It also promotes the recognition of interrelated elements (E4).

Whereas, all enterprise architects (E1–E3) named the documentation of a reference architecture as a document to be compiled, ITO experts (E4 and E5) did not. Due to the fact that in case 1, real architecture development takes place in IT projects, a reference architecture constitutes as a concept for system development and, thus, is essential for the success of strategical planning with EAM. Additionally, creation of target architectures were stated in the cases E2–E5. Expert 1 stated that the creation of a target architecture is impossible in his organisation due to its general conditions. Expert 3, in particular, emphasized that only by an assignment of costs to architectural elements a comparability of different target architecture variations is possible.

Patterns are collected (E1), documented and used as rules to solve recurring problems in IT projects and, furthermore, summarised in pattern catalogues. At the same time, essential data objects and responsibilities in business domains are documented to help project leads and IT architects. This documentation is also helpful for the avoidance of overlapping responsibilities and difficulties due to redundant definitions of data objects that are (re–)used organisation wide also in other IT projects. With it, interface management for the integration of IT systems is also supported.

The documentation of an as–is architecture is the foundation for decision making and creation of target architectures, stated by advisory enterprise architects (E2 and E3). Additionally, the documentation of current or future states of IT systems landscape were specified by experts 2 and 4. Here, configuration management databases are used and seen as data warehouses. This helps to document elements of IT systems landscape that are connected to building blocks of business architecture. Only expert 5 stated that this connection is not explicitly documented in his area of responsibility. Experts E2–E5 also made statements about tools to capture an as–is architecture. So, special tools exist to capture elements of current IT systems landscape automatically (e.g., scanner or agents), which store acquired data in repositories or configuration management databases (CMDB). But, with it, only technical elements can be discovered, some information like responsibilities remain hidden. Additionally, non–automatic discovery exist (e.g., interviews or workshops) to correct these differences or errors. With the help of capturing these elements, the as–is architecture is to be reconstructed manually. Due to the facts that different (automatic or non–automatic) sources might be used to reconstruct an as–is architecture and information are, thus, available in different formats (e.g., printings), it is, therefore, necessary that these information are to be transferred into standardized formats (e.g., tables), so expert 3.

Also the creation of a capability framework is important for EAM (E3). A capability framework is seen as a definition of organisational structures, processes, roles and responsibilities to assure a successful architecture planning and implementation [4]. From the expert 5's point of view, macro and micro solution concepts are, additionally, documented. The use of viewpoints is essential to create a holistic description of architectural elements and relationships like locations, sourcing, and important applications. Architectural diagrams are used to illustrate individual or isolated facts (e.g., systems, relationships, or data interchange). The documentation of IT systems landscape mostly consists of elements like hardware, software, server, databases, network, service level, or contact persons. The visualisation of a complete IT systems landscape is considered impractical due to its possible size (e.g., 30,000 servers in case 4). In reference to an existing IT systems landscape, accounting data is, additionally, documented (e.g., depreciation of hardware). Function tests for quality assurance before start of operation are documented as well (E5).

Besides organisations, which do not have any documentation of enterprise architecture or IT systems landscape, other organisations are using non–formal descriptions for documentation mostly (E2 and E3). This means that most documentations do not comply to any regulation (e.g., textual descriptions with visualisations). Formal representation are achieved by using repositories or standardised forms, sometimes published on a central point to create transparency (E4 and E5). In contrast (E5), documentation is also stored decentralised and hidden (e.g., every team has own and non–shared documentation about its area of responsibility).

Different tools are used for documentation of enterprise architecture and IT system landscape:

- tools for documentation of business domains,
- non–specialised tools for documentation and modelling (e.g., office suites),
- special tools for planning and documentation of enterprise architectures,
- modelling tools, and
- collaboration tools (e.g., email or workflow).

Furthermore, different modelling languages are used to document enterprise architecture and IT system landscapes. From the enterprise architects' point of view, mainly standardised modelling languages, like Unified Modeling Language (UML) or Business Process Modeling Notation (BPMN), are used and determined by modelling tools. Besides, languages with own syntax are also used, but are very similar to UML (E3). In contrast, from the ITO experts' point of view results are completely different. Here, visualisations are mainly created by the use of own syntax. UML is, according to expert 4, too complicated and, thus, cannot be used. Expert 5 stated in the rare case that standardised modelling languages are used, then UML or entity relationship (ER).

C. Enterprise Architecture Changes

The main reason for enterprise architecture changes are new or changed business requirements due to addition of other components, views on further organisational areas, changed relevance of architectural elements, organisational changes, or changes of surrounding conditions. This includes also current trends in technology (e.g., cloud computing or virtualisation) or organisational and technical consolidations. Enterprise architecture is changed also due to growth of applications or usage in new fields (E4). Both could lead to new IT infrastructure requirements (e.g., high availability solutions), whereupon the IT architecture is to be updated. In addition, expert 5 stated configuration changes for the purpose of optimization, debugging, or updates not induce changes of enterprise architecture. These configuration changes are, rather, performed to maintain the current enterprise architecture.

In reference to the frequency of changes, all experts stated an enterprise architecture is subject to continuous changes, but not necessarily a regularity is indicated. Furthermore, it can be stated that an enterprise architecture is, despite continuous changes, relatively static and changed in the long term. According to expert 4, this applies especially to core systems (e.g., ERP or CRM). IT configurations, in contrast, have a higher alteration rate than the corresponding IT architecture.

As a trigger for implementation of architectural changes, all experts stated the same that when the necessity of changes exist and resources are available, they will be implemented. Necessity of changes arise if decisions about changes have been made, or technology is worn. Latter, is insofar of interest that the replacement of technical elements (e.g., hard disks, etc.) is used as a trigger to implement upcoming architectural changes at the same time. Also changes of IT configurations are, likewise, used as a trigger. This means configuration changes are not a reason for enterprise architecture changes, but are definitely to be seen as a trigger for implementation.

D. Transition into IT Operations

In case 1, no direct responsibility for transition of enterprise architecture into IT configurations exists for an enterprise architect due to the fact project management is prescribed by the used method HERMES (like the German V–Model)[2] and no link to EAM is defined. So, IT architects are responsible for the realisation of enterprise architecture in each IT project. To accompany the transition, IT architects are also engaged in the other cases, but enterprise architects are, nevertheless, directly involved. Expert 2 stated that for software development within the scope of EAM a standardised software development process is used. For definition of required IT systems landscape, as well as for the operational processes, an operating handbook is to be defined as the interface to ITO. Furthermore, the IT organisation itself is subject to changes during transition of enterprise architecture into ITO (E3). In case 4 standardised forms are used, which define the process of transition. By completing these standard forms, a target enterprise architecture is refined successively and, at the end, these forms describe elements of targeted IT systems landscape. Expert 5 reported that in ITO, additionally, deployment and operation processes are to be differentiated, oriented at IT infrastructure library (ITIL). Although expert 1 is not directly involved in transition of enterprise architecture into IT configurations, he is still able to influence by the creation of fundamentals, like determination of a reference architecture, definition of patterns, standards, and standard protocols as well as with definition of business domains (data objects). In addition, each enterprise architect stated that decisions made by an architecture board are essential for a transition. Decisions are made on the basis of analysis, leading to target architectures that are, likewise, the foundation for transition.

Persons in different roles were stated, which are involved in the transition process directly or indirectly. First of all the role of enterprise architect (E1 to E3) or an (enterprise) architecture team (E4 and E5) were to be identified. In addition, every interviewee stated that for diverse tasks in transition process experts are consulted (e.g., IT architect, technical solution manager, technical design authority). These experts are specialised on the implementation of a certain part of an IT solution and perform a translation task from enterprise architecture into IT configurations. So, they constitute a intermediate connection between EAM and ITO. Here, the transition is actually taking place. From the ITOs' point of view, further specialists from technical teams are also employed for technical construction and operation.

Instruments used for transition are diverse. Expert 1 mentioned a standardised method, The Open Group Architecture Framework (TOGAF), to that his tasks may correspond, but the direct application is impossible. In his case, due to the lack of integration of HERMES and TOGAF. Advisory enterprise architects, likewise, mentioned the standard framework TOGAF (E3) or a TOGAF oriented, company–wide framework (E2). The definition of a roadmap is, additionally, an important instrument for transition (E2) to define future states of an enterprise architecture at certain points in time, which induces also the implementation. So, a roadmap documents milestones and packages. One package includes, thereby, a subset of target architecture elements, which are to be implemented at a certain point in time (milestones). In each package, application related software components and corresponding IT infrastructure elements are defined. These elements are to be deployed on many different locations. Expert 4 mentioned the usage of standard forms as an important instrument for transition as well as cost evaluation of derived IT infrastructure requirements. Although decisions are already made in EAM, the cost evaluation of IT infrastructure requirements during transition stage could also lead to renewed changes of architecture because implied technical solutions can cause violations of budget or technical restrictions. Hence, attendant talks with decision makers are, likewise, important instruments. Technical solutions consist of IT infrastructure elements and relationships (e.g., mem-

[2] see http://www.hermes.admin.ch/

ory, storage systems, hardware, and network) as well as characteristics (e.g., service level agreements (SLA), energy consumption). In case 5, defined operation processes are all oriented on IT infrastructure library. A quality assurance is also used to check, whether a configured IT systems landscape fits to target architecture.

The transition is supported by a variety of tools: for creation of software versions and releases during software engineering, tools for change management, release management, or configuration management, and tools to support procurement process as well as communication tools.

During transition different models are created. In particular, deployment models are important to define locations of elements on different levels of abstraction (e.g., spatial deployment of data centers, hardware deployment inside data centers, hardware inside racks, software on hardware). A special type of deployment models is constituted by sourcing models that capture which parts of an IT infrastructure will be purchased from third–party suppliers. Another type of models is constituted by layout models that define the relationship of elements (e.g., network, facility and cables for power supply and network). Expert 2 creates for each roadmap package, one operational model for elements of a target architecture. An operational model consists of a logical and a physical viewpoint. With a logical operational model (LOM) all logically related IT infrastructure elements are combined and, with a physical operational model (POM), deployed to physical, concrete hardware units. A logical operational model consists, moreover, of a conceptual operational model (COM) and a specification level of operational model (SOM). With a conceptual operational model a connection will be established between application components and IT infrastructure elements and it illustrates the deployment of software on hardware. Here, a description of IT infrastructure is abstract and independent from specific products. From COM via SOM to POM, a description of IT infrastructure elements is getting concrete and refined.

The successful implementation of an enterprise architecture is bound on a variety of factors. Communication inside an enterprise architecture board is important to have influence on transition. Furthermore, creation of transparency is important in order to establish a common understanding about an enterprise architecture to each stakeholder participating in transition process. Additionally, an iterative approach for planning IT infrastructure is advisable (E4), whereby continually consultations between EAM team and transition teams are to be hold. Due to budget or technical restrictions, a technical solution space could be limited, so a final technical solution might appears suboptimal to enterprise architects. Nevertheless, an examination of technical and financial feasibility is important for a success of transition. Also creation and delivery of an operating handbook is essential for a successful transition (E2). Thereby, care is to be taken to ensure that models of application components to operational models of IT infrastructure are modeled seamlessly. So, interdependency of IT infrastructure elements and business requirements are maintained. Hence, a seamless integration of EAM and ITO represents an essential factor of success (E3).

E. Problems

First, all experts stated problems regarding to complexity of remit and effort in planning or implementation of enterprise architectures. Complex organisations lead to complex enterprise architecture and trying to cope with that complexity causes effort. So, expert 1 reported that especially in his case, with the concentration on collaboration and communication, governance of planning and implementation is complicated. Additionally, effort originates through inflexible, non–extensible architectures and by the use of different systems for the same business case (E2 and E3). Expert 3 stated that effort, furthermore, originates by the use of EAM itself. EAM processes have to be implemented, enterprise architects have to be trained, and planning and implementation requires resources. From the ITO's point of view (E4), effort originates due to the usage of non–standardised modelling languages because everybody who is involved in the process has to train an unknown syntax beforehand. In addition, he explained that by the use of non–standardised modelling languages information loss could occur, which is the cause for misunderstandings. On the other side, effort originates also from the usage of complex, standardised modelling languages. He, nevertheless, prefers a certain standardisation, but denies the usage of a complex terminology. A middle course should rather be taken. Additionally, expert 5 stated that a distribution of knowledge about IT systems landscape leads to avoidable effort during analysis for optimisation and debugging.

Secondly, missing knowledge about the business context of IT systems within an as–is architecture description was mentioned as a problem area (E2, E4, E5). The lack of business context in the form of a business architecture significantly influences decisions about IT solutions and, hence, requires effort. An as–is analysis of enterprise architecture is only sensible when such a business architecture is documented and assigned to a certain IT systems landscape. Here, expert 2 noted that a documentation of this business architecture is missing in some organisations. A business architecture is not discoverable automatically, as it is possible for IT systems landscapes. So, assignment of IT infrastructure elements to business meaning of IT systems is necessary afterwards, if this was not done during planning. Additionally, business architecture is not stored in configuration databases, so, in cases of analysis, a reconstruction is necessary as well.

Thirdly, every expert reported that a seamless integration between EAM and ITO does not exist currently. A seamless transition is, on this occasion, considered as ideal because the manageability of tasks can be simplified the more consistency is to be reached (E3). Here, a formalisation of EAM and ITO processes is useful (E4). Advisory enterprise architects equally stated that even a gap exists between EAM and ITO. The responsibility of an enterprise architect ends with the definition of an operational model and an IT organisation is responsible for the actual implementation (E2). Additionally, expert 5 reported that EAM and ITO are not compatible to each other as well as areas inside ITO itself. Different levels of detail in descriptions of enterprise architecture and IT configuration are also a problem so that architectural descriptions cannot be used directly by ITO (E2 and E3). Expert 3 reported, additionally, he observed that ITO lacks understanding of enterprise architecture sometimes, which can be attributed to unawareness about business processes by ITO (E5). At the same time, expert 5 observed that enterprise architects also have a lack of understanding about ITO processes. Furthermore, he stated that the missing synchronisation at finding technical solutions from different viewpoints of system teams (databases, operating systems) is a problem as well. Architecture planning is sometimes unrealistic (E4). Enterprise architects create ideal solutions that differ from ideas of ITO because of budget and technical restrictions.

Fourthly, management of knowledge and experience was identified as a problem area. Effort occurs during maintenance of existing documentations (E1). Also in–time supply of information for decision making and communication is of importance, when expert 1 stated that this is the core challenge in his area of responsibility. Expert 2 considers it a problem if many of his customers do not have an overview of their used IT systems and, thus, leads to inaccurate planning. Additionally, knowledge about enterprise architecture and IT systems landscape is sometimes stored redundantly, which has consequences on the actuality of data and maintenance effort, even it is stored in CMDBs. Expert 5 reported that getting a consistent overview over the own data center is difficult due to inaccurate data in a CMDB, not consolidated knowledge about IT systems landscape, and decentralised data management. In addition, he stated that access is also restricted due to security reasons by other system teams, which, hence, complicates his daily work.

Fifthly, the maturity level of EAM was mentioned by experts 1, 3 and 5. In case 1, this is evident in that effect that the enterprise architect has not a position of power and, therefore, architecture development is not influenced directly. He is a missionary in his role and must advertise strategic planning of enterprise architecture regularly. This is similar described by expert 3, when he said that EAM is not established in some organisations yet and, thus, having a low level of maturity. In that way planning and implementation of enterprise architecture is only done, if it appears necessary for an organisation and resources are available. In case 5 an overall process for planning and implementation of enterprise architecture is not existent. Actually, this is done ad–hoc so that he is demanding an overall process to integrate EAM and ITO.

The last identified problem area affects the possibility for automation of processes during planning and implementation of an enterprise architecture. A full automation is excluded, assessed as not useful and, thus, rejected by experts. But partial automation of standard tasks to support processes is reasonable and will be of great importance in future. Techniques like model driven engineering (E3), as well as partial automation for the implementation (E2), are assessed as useful. So, the discovery of as–is architecture is partially automatable as well as the deployment process (configuration of software and IT infrastructure elements; services), if necessary information are described with a standardised language (E2, E5).

IV. Derived Requirements

A. General Constraints

Different general constraints could be identified (Table II). First, a translation exists between business areas and the operation of IT systems landscape (*GC.1*). Thereby, business requirements from IT supported business areas are translated into planned IT infrastructure elements. Translation is taking place in two steps (EAM2ITIM and ITIM2ITO — Figure 2).

TABLE II
General Constraints Derived

No.	*General Constraint*
GC.1	Translation with two steps exists, from business requirements to planned IT infrastructure elements.
GC.2	Therefore, two interfaces exist (EAM2ITIM and ITIM2ITO).
GC.3	Different model types, modelling languages, and documentation formats are used in each area of responsibility.
GC.4	Different tools are used in each area of responsibility.
GC.5	Different methods are used in each area of responsibility.

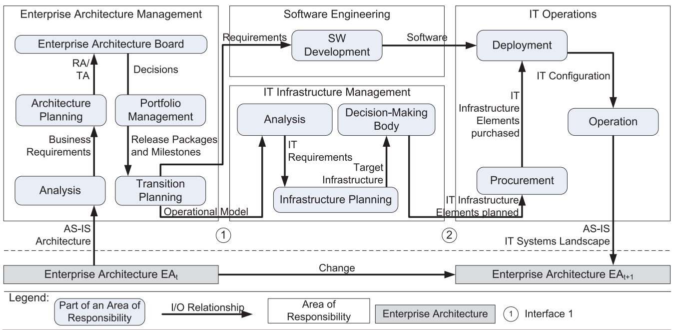

Fig. 2. Reconstructed Transition

The first translation step is constituted by *Enterprise Architecture Management*. Hereby, business requirements are collected by analysing an *as–is enterprise architecture* EA at the time t and validity is checked regarding potential changes in surrounding conditions. After that, a *reference architecture (RA)* is being build as well as *target architectures (TA)*. Afterwards, the *enterprise architecture board* decides about realisation and temporal interdependencies of *architecture changes*. These decisions are the foundation for *portfolio management* that provides different target architectures bundled into *release packages*, documented in *operational model* and milestone–based scheduling. If custom software should be required then, additionally, requirements for software development are documented. Dependencies between IT infrastructure and required custom or standard software are, likewise, documented within the operational model. *Software Engineering (SE)* and *IT Infrastructure Management (ITIM)* constitute the second step of translation. *Software packages* are provided by software engineering according to planned target architecture[3]. Simultaneously, the operational model is analysed and translated into *IT requirements*. Afterwards, *technical solutions* are engineered by IT infrastructure specialists out of these IT requirements (e.g., storage, network, operating systems, middleware, or databases) and documented in *target IT infrastructure models*. Decisions about which IT infrastructure element is needed for implementation of target architecture are made by a *decision–making body* after checking technical and economical feasibility. These decisions are used as specification for the *procurement* department to purchase missing IT infrastructure elements (in– and out–sourcing). With the *deployment* phase, *IT configurations* for required IT infrastructure elements and software are implemented (in– and out–sourcing). Now, they serve to provide a new *IT systems landscape*. Afterwards, it is one part of the changed Enterprise Architecture EA at the time $t+1$.

Secondly, two interfaces, therefore, exist for the integration of EAM and ITO (*GC.2*).

Thirdly, different types of models, documented in different modelling languages and formats, are, thereby, interchanged in between. Because models are specific for certain concerns of stakeholders it is to be assumed that this fact is still relevant as a general constraint for integration (*GC.3*).

Fourthly, different tools are used in each area of responsibility and, due to the fact that they are specialised, it is to be assumed that they will still be used during integration (*GC.4*).

Lastly, different methods are used and based on predefined or standardized (mandatory) process models. So, it is to be assumed that they are to be retained for integration (*GC.5*).

B. Quality Requirements

Six quality requirements were to be identified (Table III). At first, effort in coping complexity within each area of responsibility should be reduced (*QR.1*). This is to be achieved by reducing used resources or execution time of processes.

Additionally, supply of information for decision making and, therefore, communication among stakeholders should be improved (*QR.2*). With it, the likelihood of misunderstandings could be reduced, which increases the quality of transition process as well as of engineered technical solutions.

Besides, actuality of data about enterprise architecture and IT systems landscape should be increased (*QR.3*), which reduces errors in decision making due to inadequate and erroneous data.

Furthermore, transparency and traceability of decisions should be increased (*QR.4*), which leads to a better understanding about relationships between as well as inside enterprise architecture and, respectively, IT configurations. This also has positive consequences on error avoidance of subsequent decisions. Hence, effort for post–deployment error correction and troubleshooting is also reduced.

[3]Simplified explanation because it was not focused in the survey.

TABLE III
QUALITY REQUIREMENTS DERIVED

No.	***Quality Requirement***
QR.1	Reduction of effort in coping complexity.
QR.2	Improvement of communication and, therefore, supply of information for each stakeholder.
QR.3	Increasing actuality of data.
QR.4	Increasing transparency and traceability of decisions.
QR.5	Increasing degree of maturity of Enterprise Architecture Management, IT Infrastructure Management, and IT Configuration Management.
QR.6	Independence of quality from individual knowledge.

By improving integration of EAM and ITO, the degree of maturity for each area of responsibility should be increased (*QR.5*). So, it is important to establish an overall transition process.

Thereby, quality of technical solutions should be independent from individual knowledge (*QR.6*) to avoid information losses.

C. Functional Requirements

Also nine functional requirements were to be identified (Table IV). Insufficient seamless integration of EAM and ITO was reported by each expert. Hence, an approach for integration should provide a seamless transition through avoidance of media discontinuity during translation (*FR.1*). So, effort is to be reduced for analysis and reconstruction of as–is architectures. Additionally, transparency about relationships of enterprise architecture and IT configuration is given as well as mutual understanding and avoidance of information losses (*FR.2*). Hence, target architectures and IT configurations must always be consistent (*FR.3*).

TABLE IV
FUNCTIONAL REQUIREMENTS DERIVED

No.	***Functional Requirement***
FR.1	Seamless transition through avoidance of media discontinuity.
FR.2	Preservation of every element relationship over each layer during transition; avoidance of the loss of information.
FR.3	Always consistent target architectures and IT configurations.
FR.4	Detection of decision impacts and avoidance of unrealistic planning as early as possible.
FR.5	Adjustment of methods, tools and models.
FR.6	Independence from a concrete modelling language.
FR.7	Ability for stakeholders to get a current and consistent overview of relevant elements, at any time.
FR.8	Recurring, manual tasks avoidance, as far as possible.
FR.9	Avoidance of knowledge losses through specialists leaving organisation.

Impacts of decisions and avoidance of unrealistic planning, through violation of budget and technical restrictions, must be detected as early as possible (*FR.4*), which reduces the likelihood of errors and effort for corrections of wrong decisions also as early as possible.

Methods, tools and stakeholder oriented models must be adjusted to each other (*FR.5*) due to general constraints *GC.3–GC.5*. Here, the integration should be independent from a concrete modelling language and, rather, support common modelling languages by adaptors (*FR.6*). So, these languages are to be fulfilling their individual purpose at best.

In being able to provide a current and consistent overview of all relevant elements in enterprise architecture and IT systems landscape for each stakeholder, at any time, an adequate supply of information is to be facilitated (*FR.7*).

To reduce effort, recurring manual tasks must be avoided, as far as possible. Instead, automation is to be used, although full automation of the transition will not be possible (*FR.8*).

In addition, the loss of knowledge through specialists leaving organisation must be avoided to maintain quality and reproduceability of technical solutions (*FR.9*).

V. Criteria for Evaluation

Evaluation criteria for qualitative research are harder to assess than in quantitative research. Nevertheless, the survey is to be evaluated to show its *objectivity of data collection*, *reliability of data collection*, and *validity of data collection and analysis* [15].

To assess objectivity of data collection, it is to be assured that results are not influenced by data collection techniques (execution objectivity) [15]. To assure that, the used research approach was determined before execution and, therefore, standardized. To confront every interviewee with same questions, a guideline was used. During execution, questions were slightly changed or rephrased, but this was inevitable to adjust them to each interviewee and interview situation. Therewith, it was to be assured that every interview had the same circumstances. Additionally, sampling was based on predefined objective criteria. Furthermore, every interview was transcribed according to same rules and determined before execution. The material for content analysis was, therefore, standardized. Hence, execution objectivity is to be assumed.

Reliability means measurements are reproducible [15]. Certainly, the exact repetition of present interviews are impossible with same circumstances. Hence, the verification of reliability for the survey is not possible directly. Due to the fact the chosen research approach is fully documented, it is, at least, possible to reproduce data collection. Hence, it is to be assumed that reliability of this survey is assured.

Validity, with its two preconditions objectivity and reliability, constitutes the most important evaluation criteria in qualitative research. Here, validity is to be assured for data collection as well as for data analysis. Statements from interviewees have to be given authentic and honest documented neither biased nor modified [15]. With the present survey it is to be assumed that all experts made their statements authentic and honestly. First of all, they are accepted as experts in each organisation. Secondly, attending experts do not know each other and each is working in a different organisation, which means agreements and organisational bias are eliminated. Furthermore, authenticity is to be assumed due to the fact all experts illustrated their statements with practical examples from their organisations or customers. In addition, no contradictory statements was to be identified, but rather congruent. Additionally, by using digital audio recording and widely accepted transcription rules, all statements were captured unmodified and unbiased. However, parts of transcripted interviews were modified as a result of absolute promise of anonymity, but this never influenced content and, therefore, validity of data collection. Different speech quality of used phones and connections led to three vague, but negligible sections in transcription, which also had no influence on the analysis of statements.

Validity is to be evaluated also for *interpretations* (*internal validity*) and for *generalisations* (*external validity*) [11]. Due to the fact results also coincide with theoretical knowledge, internal validity is to be assumed. Furthermore, all derivations of requirements from interviews are documented consistently, so interpretations are traceable and transparent. In contradiction to the quality research approach used [9], which proposes to construct a set of categories based on 10–15 per cent of data material, this was increased to 100 per cent. This led to the consequence that external validity was increased as well. Because experts are to be seen as representatives of a group and the fact that two experts were consultants increased the validity of generalisations, as well.

This survey is, hence, valid according to data collection and analysis. Nevertheless, derived requirements are based on inductive conclusions, so additional or modified requirements cannot be excluded. But, due to the fact validity is given, it is to be assumed that fundamental results are not affected. Validity of generalisations for derived requirements is, therefore, also given.

VI. Conclusion

Experts were stimulated to report about (1) different and common experiences using Enterprise Architecture Management, (2) their current activities to integrate Enterprise Architecture Management and IT Operations, and (3) occurring problems and solutions. As a major result, this survey showed that an unwanted gap between Enterprise Architecture Management and IT Operations exists as well as current state of integration is insufficient. So, five general constraints, six quality requirements, and nine functional requirements were to be identified for improvement.

To increase quality of processes and technical solutions and to decrease effort in planning and implementation of Enterprise Architecture, a seamless integration is to be seen as ideal.

Consequently, the goal of a seamless integration and, thus, to automate the transition from a target enterprise architecture to an implemented IT configuration promises the resulting configuration is

1) aligned with business requirements,
2) traceable and transparent, and
3) quality does no longer depend on an individual knowledge.

Additionally, not only the configuration management itself profits from it, but also an automatic provisioning of IT systems landscapes.

So, to develop a Model Driven Engineering (MDE) approach, called *Model Driven Configuration Management (MDCM)*, for integrating Enterprise Architecture Management and IT Operations from derived requirements is work in progress and subject to further research. The identified gap between both areas shall be closed by model driven engineering techniques in a way that

- the deployment of software in an IT system landscape and
- the configuration of the underlying IT infrastructure

can be accomplished automatically and traceable during transition or migration. The usage of this approach in "declarative application deployment and change management" with complex ERP systems (e.g., SAP) showed a first successful implementation [16].

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