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ABSTRACT

Enterprise architecture management (EAM) is expected to provide business value by guiding the continuous development and transformation of an enterprise. Based on the approach we strive for constructing useful artifacts that guide the successful and situational design of EAM. In order to do so we argue for a thorough analysis of the design problem in advance. This is realized by a two-step survey conducted on EAM practices. The empirical analysis reveals eight determining design factors of EAM, a delineation of three different types of EAM design in the form of clusters as well as insight about the successfulness of the different types.

Keywords

Enterprise architecture management, design science research, problem analysis, empirical analysis

1. INTRODUCTION

Enterprise architecture (EA) describes the fundamental structures of a company (or government agency) and enables its transformation by bridging the gap between business and information technology (IT). Enterprise architecture management (EAM) is concerned with the establishment and continuous development of EA. As such, the notion of EAM goes beyond EA modeling and includes the management tasks of planning and controlling business change from an architectural perspective.

EAM is established in a growing number of companies and government agencies but there is only limited transparency about which conditions have a positive effect on the successful adoption of EAM as a holistic approach. EAM is always comprised of a multitude of complementary approaches such as architecture design, modeling, graphical representation, change management or stakeholder management, to name just a few. In scientific literature as well as in EAM practice, such solutions have been developed individually. A combination of useful solutions for partial problems might not necessarily constitute a suitable overall EAM approach, though. Our aim is to look at EAM as one complex approach, i.e. we do not want to focus on specific aspects or views but on the entirety of EAM.

Methodically, we refer to the design science research (DSR) approach as described by Hevner et al. [12]. DSR is a vividly discussed and applied research approach and is concerned with problem solving and developing useful artifacts. DSR aims at designing general design solutions that address a class of problems instead of a specific problem. Literature reflecting DSR deals with research processes [24], the role of theory [33] and with the evaluation of artifacts [5].

However, not many publications within the DSR community put emphasis on problem analysis. This is surprising taking the wickedness of problems that are subject of DSR research into account: While there may be rather narrowly defined problems where artifact building is either trivial or can employ design methods, e.g. from computer science, a large number of problems in DSR, including EAM, involve some kind of management activities and therefore tend to be more complex. As Pries-Heje and Baskerville argue, complex or *wicked* problems need to be treated differently that simple problems because they lead to asymmetric criteria decision situations [25]. Typical topics that have been addressed in the conference series on Design Science Research in Information Systems and Technology (DESRIST) involve organizational change, workflow systems, knowledge management, innovation management, business process design, and requirements engineering. All these topics include management aspects and fulfill the criteria of wicked problems: "poorly formulated, confusing, and permeated with conflicting values of many decision makers or other stakeholders" [25].

We argue that for wicked problems the step of understanding and maybe theorizing the problem is vital before starting to actually build the artifact. Therefore in this paper we focus on the step of problem analysis in a DSR process: In order to effectively understand the problems in EAM it is necessary to gain insight into the fundamental structure and characteristics of EAM design that can

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be distinguished. Therefore we aim at answering the following research questions:

- *What factors describe the design of EAM?*
- *What types of EAM design can be distinguished?*

We will ground our problem analysis on empirical data about existing, implemented EAM approaches in companies. Thereby, we aim at a thorough understanding of their inherent design and usefulness in terms of realization of their potential value. Our study is based on a questionnaire survey conducted with EAM practitioners (see section 3.1). Based on this sample we are able to explore inherent structures of EAM design. Factors influencing the design can then be used to develop useful artifacts that give guidance on the situational design of EAM.

The paper is structured as follows. In chapter 2 we outline conceptual foundations of the task of problem analysis within DSR and of EAM. Our empirical analysis is then presented in chapter 3. Based on a questionnaire (3.1) we have conducted a factor analysis (3.2) and a cluster analysis (3.3). In order to gain insight into the utility of the different EAM approaches found in the first analysis, we have conducted a second survey on the realization of EAM use potentials, which is described in chapter 4. Finally, chapter 5 integrates and discusses the findings of both surveys and gives an outlook on further research activities that may tie in with our results.

2. CONCEPTUAL FOUNDATIONS

2.1 Problem Analysis in DSR

DSR is engaged with the rigorous construction of useful IS artifacts, i.e. constructs, models, methods, or instantiations [20]. Artifact development in DSR is a problem solving process [12] and starts off with the identification of a problem that is going to be addressed [e.g. 4, 24, 29, 35]. A useful artifact is expected to solve a relevant business problem and to provide utility to the organization applying it. At the same time the artifact should be sufficiently general and address a class of design problems. As utility and generality can be conflicting goals, the concept of situational artifacts has been introduced [36]. In order to develop artifacts that are adaptable to different design problems within a problem class, the delineation of the design problem becomes a crucial task.

Considering the complexity of the underlying design problem and with the goal of situational artifact construction in mind, we argue that understanding and analyzing the problem is an essential part of building a useful artifact as a design solution. In doing so, it is important to understand the dimensions/design factors, parameters, generality and granularity of problems and possible solutions [36]. Winter proposes a procedure for developing situational artifacts based on a thorough problem analysis [36]: (1) Initial delineation of the design problem class, (2) identification of potential contingency factors based on literature analysis, (3) field study based analysis of design problems in practice in order to derive design factors, (4) refined specification of the design problem class, (5) calculation of the similarity of different design solutions, (6) determination of a useful level of generality, (7) specification of design situations. We will apply this procedure in this article by conducting an empirical analysis in order to identify design factors of EAM design and to achieve a more detailed specification of the design problem class EAM.

2.2 Enterprise Architecture Management

Most authors agree that EA targets a *holistic scope* and therefore provides a broad and aggregate view of an entire company or government agency [26, 31]. The ANSI/IEEE Standard 1471-2000 defines architecture as "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" [13]. Relevant architectural views are strategic positioning, organizational structure, process organization, information flows, and implementation by means of software systems and data structures [15, 17, 38]. EA can provide systematic support to organizational change that affects business structures as well as IT structures by providing constructional principles for designing the enterprise [7]. In order to provide support for transformation in an efficient way, EA has to be driven by business and/or IT oriented application scenarios [37] based on stakeholders concerns [22, 23, 39] (*goal orientation*) [17, 26]. Since the involvement of heterogeneous stakeholder groups may create conflicting requirements in a complex environment, an appropriate documentation and communication of EA is vital. A suitable degree of *formalization* is needed in order to ensure traceable and repeatable results. Furthermore (semi) formalized models and well structured methods are needed to enable division of labor among the stakeholder groups [10, 14].

In the field of EAM a lot of methods have been developed [2, 3, 6, 30, 34]. These methods typically comprise the following EAM processes: (1) strategic design of an architectural vision, (2) development and maintenance of as-is architecture models, (3) development and maintenance of to-be architecture models, (4) migration planning, (5) implementation of EA, and (6) analysis of EA on the basis of architecture models. Furthermore, communication and lobbying of architectural guidelines and principles are part of EAM processes [28].

Aiming at a deeper understanding of the constituent factors that influence EAM, there has been some scientific effort to analyze contingency factors of EAM. Aier et al. [1] have identified three factors that describe three aspects of EA focusing on models, data, and organizational penetration. However, they did not explicitly consider management aspects of EAM. Leppänen et al. [18] took a first step towards a complex contingency framework for an engineering method for EA. Ylimäki [39] conducted several studies in order to identify potential critical success factors for EA. Ylimäki found the following factors: commitment, governance, methodology, EA models, project management, training and education, organizational culture, IT investment strategy, assessment and evaluation, business-driven approach, communication, and scope. These success factors give a first insight into possible design factors of EAM. Therefore, we have used this set as a starting point for our study design.

3. EXPLORING EAM DESIGN

Following the problem analysis approach described by Winter [36], we have conducted an empirical analysis that examines EAM design approaches (our design problem) currently applied in practice. This analysis allows for a refined specification of different EAM designs based on descriptive factors (see section 3.2) and a specification of different types of EAM designs (see section 3.3). The analysis has been carried out via a questionnaire-based survey to address a large number of different organizations.

3.1 Questionnaire and Data Set

The questionnaire has been designed to describe EAM approaches by means of constituting aspects which have been identified in advance based on literature analysis. In order to distinguish different EAM approaches, the first part of the questionnaire has asked for the organization's understanding of the notion "EAM". The understanding in terms of the tasks and results of EAM can be manifold and is crucial to EAM design within the respective organization [32]. Second, the positioning of EAM within an organization is expressed by its integration into the organizational structure. The way organizational units, teams and roles are involved in the EAM processes is an expression of this aspect [21, 32]. Other important criteria in this context are the scope of EAM processes, the penetration of EAM processes and EAM results throughout the organization as well as the level of continuity and controlling of EAM processes. Finally, the types of EAM results that are used by different organizational units play an important role in EAM design.

Table 1. Absolute Number of Returned Questionnaires Grouped by Industry and Size of Organization

	Number of Employees						
Industry	**20-49**	**50-99**	**100-249**	**250-499**	**500-1000**	**>1000**	**∑**
Manufacturing	0	0	0	0	0	6	6
Retail	0	0	0	0	1	4	5
Telecom.	0	0	0	0	1	8	9
Financial	0	1	1	4	3	21	30
Insurance	1	0	1	0	0	6	8
Public Admin.	1	0	1	3	1	8	14
Software/IT	4	0	3	2	3	3	15
Other	1	2	2	1	4	22	32
Total	**7**	**3**	**8**	**10**	**13**	**78**	**119**

Table 2. Factor Analysis Results

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
Item 1.1	0.8005	0.1414	0.0584	0.1482	0.1741	0.0005	0.1250	0.1625
Item 1.2	0.7344	0.1076	0.0963	0.3178	0.2019	0.0961	0.1093	0.1141
Item 1.3	0.6653	0.0131	0.2617	0.3951	0.1362	0.1635	0.0107	0.1141
Item 1.4	0.5700	0.3222	0.0473	-0.1345	0.0492	0.0976	0.4473	-0.1242
Item 1.5	0.5103	0.2223	0.3147	0.0360	0.0224	0.2129	0.1296	0.3467
Item 1.6	0.5041	0.4041	0.1099	-0.0587	0.3947	-0.0328	0.2592	-0.0511
Item 2.1	0.1543	0.6984	0.0718	0.1489	0.1571	-0.0091	0.1917	-0.1022
Item 2.2	0.1662	0.6790	0.2116	0.1783	0.1376	0.1001	-0.0594	0.0959
Item 2.3	0.2192	0.6727	0.2571	0.1340	-0.0934	0.1851	0.2520	0.1019
Item 2.4	0.1005	0.6171	0.1932	0.0900	0.2565	0.0309	0.1163	0.4120
Item 2.5	0.0504	0.5903	0.0612	-0.0424	0.0523	0.2221	0.1369	0.4311
Item 2.6	0.1472	0.5445	0.0860	0.4527	-0.0052	0.0370	0.0584	0.2522
Item 2.7	-0.0470	0.5422	0.0985	0.2524	0.3363	0.2609	-0.1153	-0.0254
Item 3.1	0.0408	0.0405	0.7838	0.0045	0.0500	0.0420	0.2519	0.2246
Item 3.2	-0.0369	0.0399	0.7828	0.0237	0.1358	0.0413	0.1264	0.3787
Item 3.3	0.2156	0.1512	0.7503	0.0456	0.2513	-0.0068	-0.0626	0.1290
Item 3.4	0.1423	0.1925	0.6954	0.1726	0.1079	0.1310	0.2415	-0.2124
Item 3.5	0.2834	0.4356	0.5383	0.0916	0.0872	0.1084	-0.0446	0.0741
Item 3.6	0.3595	0.2582	0.5229	0.0661	-0.1861	0.2791	0.0940	0.2506
Item 3.7	0.1328	0.2919	0.5215	0.1928	0.1498	0.2199	-0.1639	-0.1297
Item 4.1	0.0425	0.1193	-0.0869	0.7153	-0.0010	-0.0447	0.3171	0.1112
Item 4.2	0.1381	0.1993	0.2465	0.6490	0.1004	0.1694	0.2107	0.0299
Item 4.3	0.3159	0.2069	0.0679	0.6006	0.0122	0.0122	-0.1052	0.3857
Item 4.4	0.4137	0.2716	0.2632	0.4316	0.2543	0.0597	0.0045	-0.1618
Item 5.1	0.3226	0.3338	0.2408	0.1384	0.6098	0.2141	0.0378	0.1362
Item 5.2	0.5143	0.2658	0.3642	0.0594	0.5146	0.0871	0.0524	0.1610
Item 5.3	0.1810	0.4383	0.2223	-0.0427	0.5080	0.1378	0.3287	0.1531
Item 5.4	0.4091	0.0184	0.2955	0.0409	0.4839	0.0180	0.1672	0.2445
Item 5.5	0.2382	0.0966	0.1071	0.4501	0.4635	0.1426	0.2576	0.2482
Item 5.6	0.4081	0.4095	0.0890	0.3137	0.4424	0.2017	0.0116	0.1022
Item 6.1	-0.0504	-0.0335	0.1975	0.0048	0.1466	0.8264	0.1755	0.1309
Item 6.2	0.1754	0.3235	0.0705	0.0613	0.1660	0.7595	0.0698	0.0980
Item 6.3	0.4109	0.3142	0.0491	0.2182	-0.1043	0.6578	0.2125	0.0363
Item 7.1	0.0474	0.1081	0.0865	0.1935	0.0899	0.2076	0.7206	0.2501
Item 7.2	0.2778	0.1232	0.2307	0.3425	0.1531	0.1181	0.6506	0.0201
Item 7.3	0.4072	0.0864	0.1453	0.3974	0.0762	0.1575	0.5480	0.0709
Item 8.1	0.1240	0.1582	0.2604	0.1934	0.1663	0.0956	0.1205	0.7207
Item 8.2	0.2578	0.1152	0.1583	0.3391	0.1612	0.1705	0.1204	0.5719
Cronbach's Alpha	**0.858**	**0.852**	**0.852**	**0.744**	**0.875**	**0.794**	**0.820**	**0.706**

The questionnaire reflects these considerations by listing the mentioned characteristics of an EAM approach as questions. The resulting questionnaire contains 54 items asking for the as-is state of EAM in the companies. The respondents have been asked to assess the current degree of realization on a 5-point Likert scale [19]. The minimum value (1) represents "not realized", whereas the maximum value (5) represents "fully realized".

Empirical data has been collected at four events on the topic of EAM. The events focused on EAM only and were attended by EAM experts from both IT and business departments, as well as IT management executives, IT service providers, and other IT users concerned with the task of EAM. The events took place in Germany and Switzerland between June and September 2009. A total of 119 data sets were collected that did not reveal substantial extent of missing data (10% at maximum).

More than half of the respondents are corporate users (53.8%), besides consulting firms or vendors (36.2%) and others. The companies that participated in the survey are mainly mid-size and large, most of them being active in the financial industry. Table 1 shows the distribution of industry and size of organization the respondents stem from.

3.2 Factor Analysis: Descriptive Factors of EAM Design

In order to identify common underlying dimensions characterizing EAM, we have applied an exploratory factor analysis using the principal component analysis. A factor analysis involves extracting a small number of latent factors among the variables in the data set. It is necessary to test the adequacy of the data set prior to applying a factor analysis. To form an adequate foundation, the data set has to meet two criteria. The first criterion is derived from the variables' anti image covariance. The anti image covers the part of the variance that cannot be explained by the remaining variables in the data set. As factor analysis aims at finding latent factors based on the data set, a data set is suitable for factor analysis if the anti image is rather low: According to Dziuban and Shirkey [8], the percentage of none diagonal elements of the anti image covariance matrix, which are non-zero (>0.09), should not exceed 25%. This holds true for the data set at hand. The second criterion involves the computation of the Kaiser-Meyer-Olkin measure of sampling adequacy. In the data set at hand, the measure is 0.87. According to Kaiser and Rice [16], this characterizes the intercorrelation among the variables within the factors found as "meritorious". In this case, the results prove that the data set is generally appropriate for factor analysis.

The factor analysis, using Varimax rotation with Kaiser normalization, have led to eight factors, including 38 items of the questionnaire (cf. Table 2). 16 items have been deleted because they were intentionally designed as control items or did not seem to contribute to the factor identification [11]. Due to some incomplete questionnaires, missing values have been excluded pair wise during factor analysis. This resulted in a total number of 109 cases contributing to the factor analysis. The items selected for the factor analysis explain 67.63% of variance in total.

In order to test the reliability of the factor scale, Cronbach's Alpha has been calculated for each factor (Table 2). For Cronbach's Alpha a value above 0.7 indicates an adequate reliability, which holds true for our data set. It must be noted that a large number of items may increase the value artificially [9]. However, in our case, the reliability analysis showes values mostly between 0.4 and 0.5 for the inter-item correlation within the factors, which indicates that the high value of Cronbach's Alpha can be regarded as valid for our purposes.

With regards to the interpretation of factors factor loadings from 0.3 to 0.4 are considered a minimal level [11]. Generally, factor loadings from at least 0.5 are considered sufficient for an unambiguous assignment to one factor. Some items in our data set show identically high factor loadings for more than one factor (Table 2). In these cases, factor assignment has been based on practical considerations. These considerations are explained in detail in conjunction with the factor descriptions below.

Table 3. Factor 1: IT Operations Support

Item No.	Item Description
Item 1.1	Results of EAM are used for IT development
Item 1.2	Results of EAM are used for coordination of IT development products
Item 1.3	Results of EAM are used for IT planning and infrastructure design
Item 1.4	IT departments perceive EAM as a useful device
Item 1.5	Results of EAM are used for analyses on architecture models (e.g. dependence analyses)
Item 1.6	IT departments use EAM results for their daily job

Factor 1 comprises items describing the concern *IT operations support* within the EAM approach. The use of results for IT operation tasks and by IT departments for their daily job characterizes this factor. Considering the items' loadings on this factor it becomes obvious that usage of EAM results as well as the perception of EAM within the organizational units concerned with IT operations exert a conjoint effect on overall EAM assessment.

Table 4. Factor 2: Enterprise Focus and Management Support

Item No.	Item Description
Item 2.1	Business and IT departments actively seek advice from architects
Item 2.2	Results of EAM are used for communications with management functions
Item 2.3	EA stakeholder are involved in EAM
Item 2.4	Management board uses EAM results for management tasks
Item 2.5	Management board perceives EAM as a useful device
Item 2.6	EAM is aligned with business objectives
Item 2.7	Architects have an extensive network within the company

Factor 2 summarizes items related to the *support of management tasks by EAM*. This is again expressed by the usage of EAM results by management tasks as well as by the perception of EAM in the management board. This factor constitutes the *antipole* to factor 1 and reveals that EAM can serve both IT and management purposes, but that these purposes are most probably not highly interrelated.

Table 5. Factor 3: EAM Governance

Item No.	Item Description
Item 3.1	EA models are assessed and evaluated regularly
Item 3.2	EAM processes are assessed and evaluated regularly
Item 3.3	There are defined maintenance processes for EA models and EA data
Item 3.4	There are defined EAM processes
Item 3.5	Results of EAM are used for documentation and tracking of EA models
Item 3.6	There is one consistent, enterprise-wide effective architecture model
Item 3.7	Architecture data is centralized with the EAM department

Factor 3 denotes the *governance of EAM* itself. Thereby, it is a characteristic not describing the execution of EAM but the maintenance of EAM. EAM governance consists of model and process assessment and maintenance and a central supervision of EA models and data.

Table 6. Factor 4: IT Strategy and IT Governance Support

Item No.	Item Description
Item 4.1	EAM is essential part of IT strategy development
Item 4.2	EAM is essential part of IT governance
Item 4.3	Results of EAM are used for IT strategy development
Item 4.4	Results of EAM are used for IT governance

Supplementing factor 1, factor 4 characterizes the *support of IT strategy and governance tasks* by EAM. Item 4.4 shows almost equal values for factors 1 and 4 (0.41 and 0.43), which may lead to the conclusion that the use of EAM for IT governance purposes may be highly correlated with operational IT tasks. Due to the contents of items 4.1 through 4.3 we decided to assign item 4.4 to factor 4.

Table 7. Factor 5: Information Supply

Item No.	Item Description
Item 5.1	Results of EAM are used for supply of information for business departments (service function)
Item 5.2	Results of EAM are used for supply of information for IT departments (service function)
Item 5.3	Business departments use EAM results for their daily job
Item 5.4	Results of EAM are used for operations and maintenance
Item 5.5	Results of EAM are used for Business/IT Alignment
Item 5.6	Results of EAM are used for moderation between business and IT departments (and among them)

Factor 5 again characterizes a support aspect of EAM: the *information supply* with EAM results, independent of business or IT purposes. The closeness to IT operations support (factor 1) is also backed by the fact that item 5.2 shows equal values for factors 1 and 5 (0.51). Factor 5 reflects the service function EAM can fulfill both for business and IT departments. Moreover the support of business/IT alignment is an essential part of this factor.

Table 8. Factor 6: Integrative Role

Item No.	Item Description
Item 6.1	EAM takes place in an interdisciplinary team
Item 6.2	EAM team and business departments continuously exchange information (e.g. in architecture boards)
Item 6.3	EAM team and IT departments continuously exchange information (e.g. in architecture boards)

Table 9. Factor 7: Design Impact

Item No.	Item Description
Item 7.1	EAM has an impact on IT (infrastructure) architecture design
Item 7.2	EAM has an impact on application architecture design
Item 7.3	EAM has an impact on business architecture design

Factors 6 and 7 comprise items describing the role of EAM within the organization. While factor 6 summarizes aspects expressing the *integrative role*, factor 7 focuses on the *design impact*. The integrative role of EAM can be realized by interdisciplinary teams and a continuous exchange between EAM roles. It can be assumed that the existence of an architecture board is part of such an organizational structure for EAM. The design impact can describe EAM's impact on IT or infrastructure, application or business architecture. The degree of design impact most probably reflects the penetration of the EAM approach throughout the organization as well as its active role.

Table 10. Factor 8: Business Strategy Support

Item No.	Item Description
Item 8.1	Results of EAM are used for enterprise development
Item 8.2	Results of EAM are used for strategic planning (e.g. product planning)

Finally, factor 8 again describes a support concern of EAM: *business strategy support*. In contrast to factor 2, items in factor 8 describe the support of explicit strategic tasks like enterprise development and product planning. Most probably, high degrees of realization of this factor correspond to a high realization of factor 2.

To summarize the results of the factor analysis three different groups of characteristics of EAM were found: Factors 1, 2, 4, 5 and 8 characterize the concern of EAM, i.e. whether EAM supports IT operations, management tasks, IT strategy, Business/IT alignment or business strategy. Factors 6 and 7 describe the role of EAM within the company (as moderator or designer). Finally, factor 3 describes the governance of EAM itself.

3.3 Cluster Analysis: Specific Types of EAM Design

In order to further specify the design problem class EAM and to assess the similarity of design problems within the class a cluster analysis has been performed upon the eight design factors found by our exploratory factor analysis. Cluster analysis aims at finding groups of respondents that apply similar EAM approaches. As they are more common and do not bear the risk of constraining the possible clusters by ex-ante presumptions [11], hierarchical clustering algorithms have been used. Those algorithms produce all possible clustering results, so the final solution must be identified based on the agglomeration schedule and the dendrogram.

Considering results from preliminary cluster analyses on the data, one case has been eliminated as it showed heavy outlier behavior [11]. Excluding cases with missing factor loadings, 94 cases could be used for the cluster analysis. For the final cluster analysis, which is presented below, we have used the *Average Within-Group Linkage* cluster algorithm provided by SPSS and *Squared Euclidean Distance* as the distance measure. The results of the agglomeration schedule and the dendrogram have led to the identification of three clusters. Based on this empirical evidence the level of optimal granularity of the design problem class EAM can be determined as three.

In order to interpret the clusters with respect to the underlying characteristics, the cluster centroids have been analyzed. These can be identified by the mean factor values within each cluster, enabling a characterization of the clusters. The mean factor values for each cluster are depicted by the net diagram in Figure 1. The clusters can be described as follows.

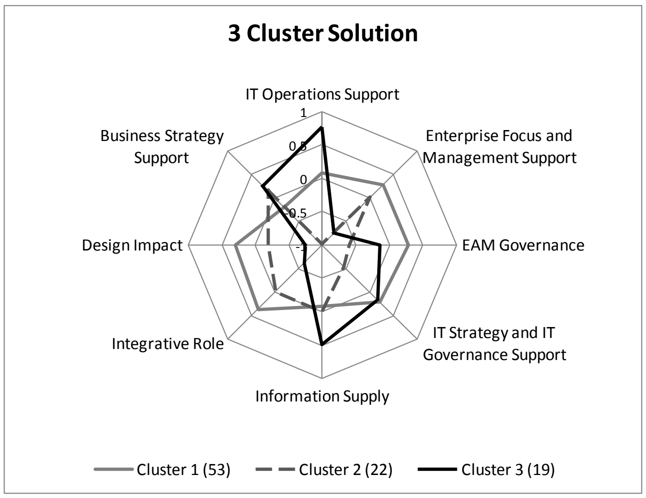

Figure 1. Net Diagram for the 3 cluster solution

Cluster 1: Balanced, active approach

The first cluster (solid line) presents a rather balanced approach to EAM. For most factors this cluster shows the highest or at least average values. Especially the similar values for the factors IT Operations Support and Enterprise Focus and Management Support lead to the conclusion that organizations within this cluster do not focus neither on IT support nor on management support with their EAM approach.

In contrast to other clusters, the high support of IT operations, management, IT strategy as well as the focus on design impact, the integrative role and EAM Governance point to a high degree of integration within the organization. In particular values for Design Impact, Integrative Role and EAM Governance are by far the highest between all three clusters. It can therefore be presumed that these organizations have a rather high level of maturity in their EAM approach.

It should be noted that this cluster includes 53 out of 94 organizations, which lead to the supposition that this cluster represents a "mainstream" approach. This can also be ascribed to the fact that the majority of participants in the survey are from large organizations (>1000 employees, cf. Table 1).

Cluster 2: Business-oriented approach

The second cluster (dashed line) groups 22 organizations that have an apparent focus on business support in their EAM approach. The factors IT Operations Support as well as IT Strategy and IT Governance Support are clearly assigned with comparatively low values. Comparing mean factor values to those of cluster 1, the overall low values imply that the organizations in this cluster do not show a high degree of EAM implementation in any dimension. Two conclusions can be derived from this fact: First, the organizations could have decided to apply a minimalist EAM approach, focusing on management support without putting resources in EAM governance or an active role of EAM. Second, the introduction of EAM could only recently be initiated by management and is not very mature yet. For both cases, literature suggests that a sustainable EAM approach can only be established by realizing an effective EAM governance [2, 3].

Cluster 3: IT-oriented, passive approach

Organizations assigned to this cluster (dotted line) clearly emphasize the use of EAM for IT operations as well as the information supply by EAM. In contrast, values for management support are by far the lowest compared to the other clusters. As the factors Design Impact as well as Integrative Role are not focused in this approach, it can be described as a passive approach that is most probably realized very locally within the organization.

Obviously, this small cluster, which includes only 19 of 94 organizations, represents a specialized IT-centered EAM approach that primarily takes a documentation role. It can be presumed that the EAM approach was initiated by IT departments and has not been disseminated throughout the organization yet.

4. UTILITY OF EAM APPROACHES

4.1 Questionnaire and Data Set

The factor and cluster analysis provide a basis for understanding different types EAM design and their constituting design factors that should be respected by a situational artifact. However, it can only be concluded that the described types of EAM design can be distinguished. The results of the analyses do not allow assessing whether a certain EAM design is "good" or "appropriate" or even "successful". Therefore, we conducted a subsequent analysis that asked for the realization of use potentials that are typically assigned to the adoption of EAM. Thereby, we aimed at assessing if a certain EAM approach is more successful than another.

A second questionnaire has been distributed at a subsequent EA expert event within the same series of events where the first survey had been conducted. The event took place in Switzerland in February 2010. 98 questionnaires were returned, with 94 questionnaires holding less than 10% missing data. Hence, 94 data records could be included in the analysis. The respondents of the second questionnaire were asked to assess the current realization as well as their satisfaction with the current degree of realization of 14 use potentials [21, 27, 32, 34]:

- Business/IT alignment
- Consistent implementation of business strategy
- Improved complexity management
- Higher flexibility in reaction to external changes

- Higher efficiency in reaction to customer and market needs, and pressure to be innovative by proactive action
- Lower risk by preparing for unplanned changes
- Fewer inconsistencies and redundancies through transparent IT functionalities
- Adoption of modern technologies
- Integration of business activities across business units
- Dissolution of information silos (e.g. CRM information)
- Lower heterogeneity of technologies in use
- Lower support costs
- Improved reusability of technologies, information, and functions
- Lower development costs

4.2 Profiling Respondents

In a first step, the respondents of the second questionnaire were assigned to EAM clusters found in the explorative analysis of the first questionnaire. In order to do so, the respondents were asked about their current realization of the eight factors upon which the clusters are based. In a first step, standard scores for these values were calculated, so that they are comparable with the factors values, i.e. the cluster profile line values from the first analysis. Standard scores have a mean μ of zero and a standard deviation σ of 1. The standard score Z was calculated using the following formula:

(1) $Z = (x-\mu)/\sigma$, while x is original value of variable

In a second step the "distance" between each respondent's profile and the three clusters' profiles were calculated. The distance was measured by the method of least squares, which is also used in regression analysis [11]:

(2) $\sum (z - c)^2 \rightarrow \min$, while z is standard score of the variable and c is the cluster profile point

This distance calculation method was performed for each respondent and each cluster. The least sum of squares designates the cluster profile the respondent is most similar to. Hence, each respondent could be assigned to cluster 1, 2, or 3. Finally, 50 cases could be assigned to cluster 1, 38 cases could be assigned to cluster 2, and 6 cases could be assigned to cluster 3.

4.3 Results: Realization of Use Potentials

By comparing the standard mean values of the respondents that are assigned to the same cluster, the realization of the use potentials can be analyzed dependent on the type of EAM design applied. In Figure 2 realization and the satisfaction of the use potentials are depicted in one diagram, divided by the three clusters the respondents were assigned to. While satisfaction with the realization is given on the vertical axis, the degree of realization itself is given on the horizontal axis. It shows that especially in cluster 1, i.e. the balanced, active approach the organizations are comparably highly satisfied with their high realization of use potentials (upper right area). In contrast to this, organizations in cluster 2, i.e. business-oriented approach show low realization and low satisfaction with it (lower left area). In addition Table 11 shows the standard means of the use potential realization variables across the groups. It becomes obvious that cluster 1 has the highest realization for each use potential. From there it can be concluded that the EAM approach represented by cluster 1 is more successful than the other.

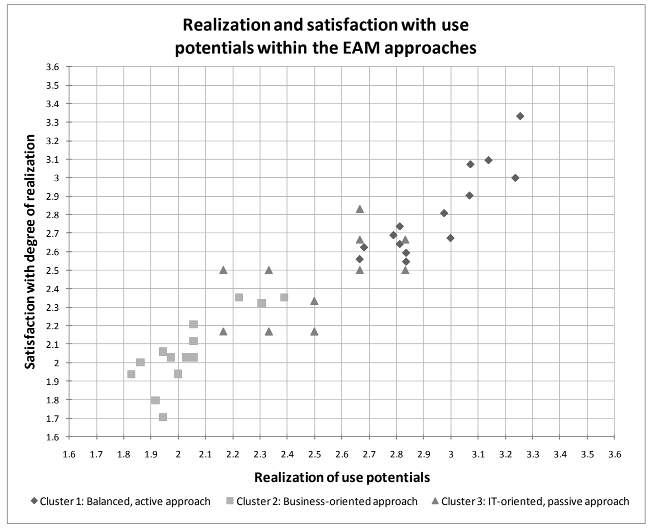

Figure 2. Realization and satisfaction with use potentials across all three clusters

Table 11. Standard Means of Use Potential Variables across all Three Clusters

	Cl. 1	Cl. 2	Cl. 3	F	Sig.
Business/IT alignment	3.07	1.92	2.50	26.039	.000
Consistent implementation of business strategy	2.84	2.03	2.33	9.446	.000
Improved complexity management	3.00	1.94	2.33	13.286	.000
Higher flexibility in reaction to external changes	2.68	1.83	2.17	8.468	.000
Higher efficiency in reaction to customer and market needs, and pressure to be innovative by proactive action	2.67	1.86	2.67	9.835	.000
Lower risk by preparing for unplanned changes	2.81	1.94	2.33	10.196	.000
Fewer inconsistencies and redundancies through transparent IT functionalities	3.07	2.00	2.67	14.723	.000
Adoption of modern technologies	3.26	2.39	2.83	6.897	.002
Integration of business activities across business units	2.98	2.06	2.83	11.344	.000
Dissolution of information silos (e.g. CRM information)	2.81	2.31	2.67	2.848	.064
Lower heterogeneity of technologies in use	3.14	2.22	2.50	10.592	.000
Lower support costs	2.79	2.06	2.17	9.889	.000
Improved reusability of technologies, information, and functions	3.24	2.06	2.50	20.869	.000
Lower development costs	2.84	1.97	2.17	12.454	.000
Legend: Cl. = Cluster, Sig. = Significance					

In order to further examine the differences between the three clusters, ANOVA was performed to analyze if there are significant differences in the realization of use potentials between the groups (clusters) [9]. ANOVA tests whether group means are equal by comparing variations within and between the groups. The comparison is expressed by the F ratio, which is the higher the more likely the difference of the values between groups is not a chance result. In our analysis, F values and significance values of ANOVA show that the null hypothesis that the standard means are equal across all groups must be rejected for all use potentials (cf. Table 11). On exception is the use potential "Dissolution of information silos" with a significance value of 0.064.

Consequently, it can be stated that the realization of use potentials is significantly different between the clusters. This means that the employment of a certain EAM design approach has an effect of the realization of the use potentials, i.e. that the three different EAM approaches are unequally successful. In the following sections we describe the three different EAM approaches regarding the degree of realization of use potentials in detail.

4.3.1 Business-Oriented Approach

Overall the business-oriented approach shows the lowest values of realization and satisfaction with use potentials and therefore seems to be the least successful approach. Among the use potentials, the variables showing the highest realization values are:

- Adoption of modern technologies
- Dissolution of information silos
- Lower heterogeneity of technologies in use

The variables showing high realization but still low satisfaction values are:

- Higher flexibility in reaction to external changes
- Higher efficiency in reaction to customer and market needs, and pressure to innovate
- Improved complexity management
- Business/IT alignment
- Fewer inconsistencies and redundancies

It is remarkable that technology-related use potentials seem to be realized more successfully although the approach is characterized by business orientation. In comparison to the other approaches that also show high values in these use potentials, it can be assumed that these use potentials can be realized by different approaches.

The list of use potentials with high satisfaction values shows that the approach lacks the realization of business-related goals. Especially an increased flexibility and efficiency in reaction to external changes and customer needs are use potentials that are often expected from business-oriented EAM. However, in this cluster the approach does not seem to be successful in this matter. Hence, this is the crucial aspect that needs to be improved and respected by an appropriate method how to design EAM.

4.3.2 IT-Oriented, Passive Approach

The IT-oriented, passive approach shows intermediate values for both realization and satisfaction with use potentials of EAM. By further analyzing this cluster it has to be considered that this can only be based on 6 cases found in the second survey. Within this cluster, the variables showing the highest realization values are:

- Adoption of modern technologies
- Dissolution of information silos
- Fewer inconsistencies and redundancies through transparent IT functionalities

The variables showing high realization but still low satisfaction values are:

- Higher flexibility in reaction to external changes
- Improved complexity management
- Lower risk by preparing for unplanned changes
- Lower support costs

The use potentials with high realization values seem to be compatible with the IT-oriented approach in this cluster. On the other side, there is a lot of improvement potential regarding reduced risks, costs and improved complexity management and flexibility. The pursuit for reaching these goals reflects the IT-orientation of this approach. At the same time, the gap between current and aspired realization leads to the assumption that the IT-oriented, passive EAM approach is not very mature yet.

4.3.3 Balanced, Active Approach

The majority of the organizations in both our surveys can be assigned to the balanced, active approach cluster. In addition, this cluster shows the highest values for realization and satisfaction with use potentials by far. The variables showing the highest realization as well as satisfaction values in this cluster are:

- Adoption of modern technologies
- Lower heterogeneity of technologies in use
- Improved reusability of technologies, information, and functions
- Fewer inconsistencies and redundancies through transparent IT functionalities

The variables showing high realization but still low satisfaction values are:

- Consistent implementation of business strategy
- Lower development costs
- Higher flexibility in reaction to external changes
- Higher efficiency in reaction to customer and market needs, and pressure to innovate

The high realization values show that although the approach is characterized as balanced between IT and business goals, IT-related use potentials are realized better than business-related ones. This can be ascribed to the high fraction of IT experts among the respondents in the survey or to the fact that many EAM initiatives in organizations are driven by IT departments. Therefore, there is still improvement potential regarding business-related goals like flexibility and efficiency.

5. DISCUSSION AND OUTLOOK

Our analysis provides the means for specifying the design problem EAM: It shows that three different types of EAM design can be distinguished. The approaches differ regarding the focus of EAM (IT or business) as well as regarding their emphasis on an active design role of EAM. The separation of one *mainstream* and two *specialized* approaches that can reliably be distinguished leads to the conclusion that there are significant differences in realizing EAM in practice. In conjunction with the analysis of the realization of use potentials, i.e. the achievement of typical EAM goals, the empirical analysis of EAM practices furthermore reveals some important details about how EAM is done and what improvement potentials still exist. These potentials should be target of future research activities in order to develop useful artifacts for the design and adoption of EAM in practice.

However, there are still some limitations in our work. First, the design factors are most probably not stable over time but will change, either over the time of application within one organization or in dependency of some other aspect. In order to ensure the reliability of the eight design factors it would also be helpful to gain information in what way they depend on other typical contingency factors that we did not examine in our research, e.g. culture, organizational structure etc. Further research towards a specification of EAM design situations should thus aim at a better understanding of the relevant contingency factors and their combination.

Moreover, it needs to be noted that the probably complex set of design factors of EAM cannot be explained fully by our research results. Although we found eight constituting factors that determine the design of EAM as it is done in practice, there is no information about how these factors interact with each other. The emphasis on one factor, e.g. regarding design impact, might limit the possible design scope of another factor, e.g. EAM governance. From our results it cannot be inferred that high values of all factors correspond to the "best" EAM design.

Our analysis clearly structured the problem domain of EAM. This is a valuable basis for a situational artifact construction in DSR. The approach of understanding a certain problem domain – like EAM in this analysis – might also provide value for other wicked problems in IS. Therefore, a more systematic in-depth analysis of the actual problems might lead to a more structured build process in DSR. As a long term goal the DSR process models should reflect such a systematic in-depth problem analysis as we have performed here.

Instead of striving for a complete understanding of the interplay of all possible contingency factors of EAM we put our focus on exploring the EAM approaches with regard to their success. From our analysis it can be deduced that the balanced, active approach showed the highest satisfaction and realization values for possible use potentials. Hence, a general conclusion is that even EAM initiatives that are at the very beginning or are intended to start within a small scope should aim at a vision that is in line with this approach. Furthermore, this result encourages the opinion that EAM should not be considered as an IT or business approach only. The comparison between the three clusters showed that a high emphasis on one of these extremes is not assessed as equally successful as the balanced approach.

Regarding the achievement of goals that are expected from EAM, the adoption of modern technologies is the highest realized use potential. By contrast the use potentials that are still not satisfied are: flexibility to external changes and reaction to customer and market needs. This result is remarkable as these are goals usually assigned to EAM and often serve as a main selling point for adopting EAM in an organization. This mismatch indicates once more that EAM cannot be realized by applying a standard or "one-size-fits-all" approach but that situational design guidance is necessary. It also shows a common dissatisfaction with the way EAM is currently done in practice. Maybe these goals can only be achieved in the long run when an EAM initiative "grows in an organization". Such a dependency on other influencing factors should be subject of further research activities.

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