What Enterprise Architecture and Enterprise Systems Usage Can and Can not Tell about Each Other

Maya Daneva, Pascal van Eck

***Abstract*—There is an increased awareness of the roles that enterprise architecture (EA) and enterprise systems (ES) play in today's organizations. EA and ES usage maturity models are used to assess how well companies are capable of deploying these two concepts while striving to achieve strategic corporate goals. The existence of various architecture and ES usage models raises questions about how they both refer to each other, e.g. if a higher level of architecture maturity implies a higher ES usage level. This paper compares these two types of models by using literature survey results and case-study experiences. We conclude that (i) EA and ES usage maturity models agree on a number of critical success factors and (ii) in a company with a mature architecture function, one is likely to observe, at the early stages of ES initiatives, certain practices associated with a higher level of ES usage maturity.**

***Index Terms* — Maturity Models, Enterprise Resource Planning, Enterprise Architecture**

I. Introduction

In the past decade, companies and public sector organizations developed an increased understanding that true connectedness and participation in "the networked economy" or in "virtual value webs" would not happen merely through applications of technology, like Enterprise Resource Planning (ERP), Enterprise Application Integration middleware, or web services. The key lesson they learnt was that it would happen only if organizations changed the way they run their operations and integrated them well into cross-organizational business processes [1]. This takes at least 2-3 years and implies the need to (i) align changes in the business processes to technology changes and (ii) be able to anticipate and support complex decisions impacting each of the partner organizations in a network and their enterprise systems (ES).

In this context, Enterprise Architecture (EA) increasingly becomes critical, for it provides to both business and IT managers a clear and synthetic vision of an organization's business processes and of the IT resources they rely on. For the purpose of this research, we use the term 'enterprise architecture' to refer to the constituents of an enterprise at both the social level (roles, organizational units, processes) as well as the technical level (information technology and related technology), and the synergetic relations between these constituents. Enterprise architecture explains how the constituents of an enterprise are related and how these relations jointly create added value. EA also implies a model that drives the process of aligning programs and initiatives with solution architectures integrating both ES and legacy applications. Observations from EA and ES literature [2], [3], [4], [5], [6], [7] indicate that, in practice, the many facets of EA and ES are commonly used as complementing each other. For example, EA and ES represent two of the five major decision areas encompassed in IT governance at high performing organizations [8]. The experiences of these companies suggest that EA is the common enforcer of standards from which a high-level strategic and management-oriented view of potential solutions can be driven to the implementation level. Moreover, EA processes are critical in implementing coordinated sets of governance mechanisms for ERP programs that simultaneously change technology support, ways of doing business, and people's job content.

However, due to a lack of adequate principles, theories, and tools to support consistent application of the concepts of EA and ES usage, the interplay between them is still rarely studied. ES usage and evolution processes and EA processes are analyzed in isolation, by using different research methods. Clearly, there is a need for approaches including definitions, assessment aspects and models that allow architects and IT decision makers to reason about these two aspects of IT governance. Examples include reasoning about the choices that guide an organization's approach to ES investments or about situations when changing business requirements can be addressed within the architecture and when changes justify an exception to enterprise standards.

The present paper responds to this need. Its objective is to add to our understanding of how the concepts of EA and

M. Daneva is with the Information Systems Group at the department of Computer Science, University of Twente, The Netherlands (phone: ++31-53-489-2889; fax: ++31-53-489-2927; e-mail: m.daneva@utwente.nl).

P.A.T. van Eck is with the Information Systems Group at the department of Computer Science, University of Twente, The Netherlands (e-mail: p.a.t.vaneck@ewi.utwente.nl).

ES usage are linked, how the processes of EA and ES usage are linked, and how those processes can be organized differently to create improved organizational results. The paper seeks to make the linkages between EA and ES usage explicit so that requirement engineers working on corporate-wide or networked ES implementation projects can use this knowledge and leverage EA assets to achieve feasible RE processes. To get insights into these two concepts, we apply a maturity-based view of the ES adopting organizations. This perspective provides grounds for the practical application of commonly available maturity models that could be used with minimal disruption to the areas being examined in a case study.

The paper is structured as follows: In Sect. II we motivate our research approach. In Sect. III, we give a background of how we use existing architecture maturity models to build a framework and provide a rationale for using the DoC's AMM [9] to mould our case study assessment process. Section IV discussed the concept of ES usage maturity along with three specific models. Section V reports on how both classes of models agree and disagree. Section VI reports on and discusses findings from our case study. In Sect. VII, we check the consistency between the findings from the literature survey and the ones from the case study. We summarize conclusions and research plans in Sect VIII.

II. Background and Research Approach

The goal of our study is to collect information that would help us assess the interplay of architecture and ES usage in an ES-adopting organization. Since research studies in architecture maturity and in ERP usage maturity have been focused either on organization-specific architecture aspects or on ES factors, there is a distinct challenge to develop a research model that adopts the most appropriate constructs from prior research and integrate them with constructs that are most suitable to our context. Given the lack of research on the phenomenon we are interested in and the fact that the boundaries between phenomenon and context are not clearly evident, it seems appropriate to use a qualitative approach to our research goal. Specifically, we chose to apply an approach based on the positivist case study research method [10], [11] because of the following: (i) evidence suggests its particular suitability to IS research situations in which both an in-depth investigation is needed and the phenomenon in question can not be studied outside the context where it occurs, (ii) it offers a great deal of flexibility in terms of research perspectives to be adopted and qualitative data collection methods, and (iii) case studies open up opportunities to get the subtle data we need to increase our understanding of complex IS phenomena like ERP adoption and enterprise architecture.

In this research, we take the view that the linkages between EA and ES usage can be interrogated via artefacts subjected to maturity assessments such as (a) visible practices deployed by an organization, (b) underlying assumptions behind these practices, (c) architecture and ES project deliverables, (d) architecture and ES project roles, and (e) shared codes of meaning that undergird what an organization thinks a good practice is and what it is not [12]. According to this view, we see maturity assessment frameworks as vehicles that help organizations and external observers integrate their experiences into coherent systems of meaning. Our view is consistent with the understanding of assessment models as (i) normative behaviour models, based on organization's values and believes as well as (ii) process theories that help explain why organizations do not always succeed in EA and ES initiatives [8],[13].

We selected architecture maturity models [9], [14], [15], [16], [17], [18] and ES usage models [5], 13], [19] as the lens through which we examine the linkages between EA and ES usage. The reason for choosing these models is threefold: (i) the models support decision making in context of organizational change and this is certainly relevant to understanding IT governance, (ii) the models suggest how organizations can proceed from less controlled to more controlled fashion of organizing architecture and ES processes and through this we can analyze how to leverage architecture and ES assets to achieve a better business results, and (iii) both classes of models provide a perspective allowing us to see the evolution of EA and ES usage as moving through stages characterized by key role players, typical activities and challenges, appropriate performance metrics, and a range of possible outcomes.

Our view of maturity models as normative systems of meaning brought us to the idea of using the methods of semiotic analysis [12], [20] for uncovering the facets of the relationship between EA maturity and ES usage maturity. From the semiotics standpoint, organizational settings are treated as a system of signs, where a sign is defined as the relationship between a symbol and the content that this symbol conveys. This relationship is determined by the conventions of the stakeholders involved (e.g., business users, architects and ES implementation project team members). In semiotic analysis, these conventions are termed codes. A code is defined by a set of symbols, a set of contents and rules that map symbols to contents [20]. Codes specify meanings of a set of symbols within organizational settings. On the manifest level, certain practices, roles, and symbols are carriers of architecture and ES usage maturity. On the core level, stakeholders share beliefs, values, and understandings that guide their actions. Thus, in order to fully understand the maturity of EA or ES usage in organization's settings, we should uncover the relevant symbols, the contents conveyed by these symbols, and the relationships that bind them. If we could do this, we should be able to get a clear picture about the extent to which the EA and ES usage maturity models agree and disagree in terms of pertinent symbols, contents, and codes.

Our analytical approach has three specific objectives, namely: (i) to identify how existing architecture

frameworks and ES usage models stand to each other, (ii) to assess the possible mappings between their assessment criteria, and (iii) to examine if the mappings between architecture maturity assessment criteria and the ES usage maturity criteria can be used to judge the ES usage maturity in an ES adopting organization, provided architecture maturity of this organization is known.

Our research approach is multi-analytical in nature. It draws on the idea of merging a literature survey and a case study. It involved five stages:

1. Literature survey and mapping assessment criteria of existing architecture maturity models.
2. Literature survey of existing ES usage maturity models.
3. Identification of assessment criteria for architecture and ES usage maturity that seem (i) to overlap, (ii) to correlate, and (iii) to explain each other.
4. Selection and application of one architecture maturity model and one ES usage model to organizational settings in a case study.
5. Post-application analysis to understand the relationships between the two maturity models.

We discuss each of these stages in more detail in the sections that follow.

III. Mapping Architecture Maturity Criteria

At least six methods for assessing the ability of EA to deliver to promise were introduced in the past five years: (i) the IT ACMM of the Department of Commerce (DoC) of the USA [9], (ii) the Federal Enterprise Architecture Maturity Framework [14], (iii) the Information Technology Balanced Score Card model [16], (iv) the models for extended-enterprise-architects [18], (v) the Gartner Enterprise Architecture Maturity Model [15] and (vi) the META Enterprise Architecture Program Maturity Model [17]. We analyzed these models by studying the following aspects:

- what assessment criteria they deem important to judge maturity,
- what practices, roles and artifacts are surveyed for compliance to these criteria,
- how the artefacts surveyed are mapped to these criteria.

Our findings indicate that these six models all define the concept of maturity differently, but all implicitly aim at adopting or adapting some good practices within an improvement initiative targeting repeatable outcomes. The models assume that organizations reach a plateau in which at least one architecture process is transformed from a lower level to a new level of capability. We found that they all share the following common properties:

- a number of dimensions or process areas at several discrete levels of maturity (typically five or six),
- a qualifier for each level (such as initial, repeatable, defined, managed, optimized),
- a hierarchical model of assessment criteria for each process area,
- a description of each assessment criterion which codifies what the authors regard as good and not so good practice and which could be observed at each maturity level,
- an assessment procedure that provides qualitative or quantitative ratings for each of the process areas.

To get more insights into how the assessment criteria of each model refer to the ones from the other models (e.g. if assessment criteria overlap, or if they complement each other), we did a comparison on a definition-by-definition basis. We tried to understand if there exists a semantic equivalence between the assessment criteria of the six models. We termed two assessment criteria “semantically equivalent” if their definitions suggest an identical set of symbols, an identical set of contents, and an identical set of mappings from symbols to contents. This definition ensures that two assessment criteria are equivalent when they have the same meaning and they use the same artifact to judge identical maturity factors. In our definition, the term ‘artifacts’ means one of the following [22]: a process (e.g. EA process, activity or practice), a product (e.g. an architecture deliverable, a business requirements document), or a resource (e.g. architects, architecture modeling tools). For example, the Operation-Unit-Participation criterion from the DoC ACMM is semantically equivalent to the Business-Unit-Involvement criterion from the models for extended-enterprise-architects (E2ACMM). These two criteria both mean to assess the extent to which business stakeholders are actively kept involved in the architecture processes. When compared on a symbol-by-symbol, contents-by-contents and code-by-code basis, the definitions of these two criteria indicate that they both mean to measure a common aspect, namely how frequently and how actively business representatives participate in the architecture process and what the level of business representatives’ awareness of architecture is.

An extraction of our analysis’ findings is presented in Table 1. It reports on a set of assessment criteria that we found to be semantically equivalent in two models, namely the E2ACMM [18], and the DoC ACMM [9].

TABLE 1. TWO ACMMS COMPARED AND CONTRASTED

E2ACMM	DoC ACMM
Extended Enterprise Involvement	
Business units involvement	Operating Unit Participation
Enterprise Program Management	
Business & Technology Strategy Alignment	Business Linkage
Executive Management Involvement	Senior Management Involvement
Strategic Governance	Governance
Enterprise budget & Procurement strategy	IT investment & Acquisition Strategy
Holistic Extended Enterprise Architecture	
Extended Enterprise Architecture Programme Office	Architecture Process
Extended Enterprise Architecture Development	Architecture Development
Enterprise Program Management	Architecture Communication
	IT security
Enterprise budget & Procurement strategy	IT investment & Acquisition Strategy
Extended Enterprise Architecture Results	
Extended Enterprise Architecture Development	Architecture Development

Next, we analyzed the distribution of the assessment criteria according to maturity levels in order to understand what the relative contribution of each criterion is to a certain maturity level. Our general observation was that the ACMMs may use correlating criteria but these may be linked to different maturity levels. For example, the DoC ACMM defines the formal alignment of business strategy and IT strategies to be a Level 4 criterion, while the E2ACMM checks it at Level 3.

IV. MAPPING UMS MATURITY CRITERIA

The ES literature, to the best of our knowledge, indicates that there are three relatively popular ES Usage maturity models: (i) the ES experience model by Markus et al [13], (ii) the ERP Maturity Model by Ernst & Young, India [19], and (iii) the staged ES Usage Maturity Model by Holland et al [5]. All the three models take different views of the way companies make decisions on their organization structure, process and data definitions, configuration, security and training. What these models have in common is that they all are meant as theoretical frameworks for analysing, both retrospectively and prospectively, the business value of ES. It is important to note that organizations repeatedly go through various maturity stages when they undertake major upgrades or replacement of ES.

As system evolution adds the concept of time to these frameworks, they tend to structure 'ES experiences' in terms of stages, starting conditions, goals, plans and quality of execution. First, the model by Markus et al [13] allocates elements of ES success to three different points in time during the system life cycle in an organization: (i) the 'project phase' in which the system is configured and rolled out, (ii) the 'shakedown phase' in which the organization goes live and integrates the system in their daily routine, and (iii) the 'onward and upward phase', in which the organization gets used to the system and is going to implement additions. Success in the shakedown phase and in the onward and upward phase is influenced by ES usage maturity. For example, observations like (i) a high level of successful improvement initiatives, (ii) a high level of employees' willingness to work with the system, and (iii) frequent adaptations in new releases, are directly related to a high level of ES usage maturity. Second, the ERP Maturity Model by Ernst & Young, India [19] places the experiences in context of creating an adaptable ERP solution that meets changing processes, organization structures and demand patterns. This model structures ERP adopter's experiences into three stages: (i) chaos, in which the adopter may loose the alignment of processes and ERP definition, reverts to old habits and routines, and complements the ERP system usage with workarounds, (ii) stagnancy in which organizations are reasonably satisfied with the implemented solution but they had hoped for a higher return-on-investment rates and, therefore, they refine and improve the ES usage to get a better business performance, and (iii) growth in which the adopter seeks strategic support from the ES and moves its focus over to profit, working capital management and people growth. Third, the staged maturity model by Holland et al [5] suggests three stages as shown in the Table 2. It is based on five assessment criteria that reflect how ERP-adopters progress to a more mature level based on increased ES usage.

Our comparative analysis of the definitions of the assessment criteria pointed out that the number of common factors that make up the criteria of these three models is less than 30%. The common factors are: (1) shared vision of how the ES contributes to the organization's bottom-line, (2) use of ES for strategic purposes, (3) tight integration of processes and ES, and (4) executive sponsorship. In the next section, we refer to these common criteria when we compare the models for assessing ES usage maturity to the ones for assessing architecture maturity.

TABLE 2. ES USAGE MATURITY MODEL (BASED ON [5])

Constructs	Stage 1	Stage 2	Stage 3
Strategic Use of IT	• Retention of responsible people • no CIO (anymore) • IS does not support strategic decision-making	• ES is on a low level used for strategic decision-making • IT strategy is regularly reviewed • High ES importance	• Strong vision • Organization-wide IT strategy • CIO on the senior management team
Organizational Sophistication	• no process orientation • very little thought about information flows • no culture change	• significant organizational change • improved transactional efficiency	• process oriented organization • top level support and strong understanding of ERP-implications
Penetration of the ERP System	• the system is used by less than 50% of the organization • cost-based issues prohibit the number of users • little training • staff retention issues	• most business groups / departments are supported • high usage by employees	• truly integrated organization • users find the system easy to use
Drivers & Lessons	Key drivers: • priority with management information • costs Lessons: • mistakes are hard to correct • high learning curve	Key drivers: • reduction in costs • replacement of legacy systems • integrating all business processes • improved access of management information	Key drivers: • single supply chain • replacement of legacy systems
Vision	• no clear vision • simple transaction processing	• performance oriented culture • internal and external benchmarking	• higher level uses are identified • other IT systems can be connected

V. MAPPING ARCHITECTURE MATURITY CRITERIA TO EA USAGE MATURITY CRITERIA: INSIGHTS FROM THE SURVEY STUDY

The underlying hypothesis is this paper is that the criteria of the ACMMs and the ones of the ES UMMs differ, correlate but do not explain one another. Table 3 summarizes the similarities and the differences of the two types of models. The rightmost column indicates that the models agree on seven factors in terms of what they contain. Table 3 also identifies significant differences between the two model types. For example, the ES usage models do not explicitly address a number of areas critical to ACMM compliance, e.g.: use of a framework, existence of communication loops and acquisition processes, security, and governance. Having analyzed the linkages between these two model types, our findings from the literature survey study suggest the following two implications for ES adopting organizations: (1) If an organization scores high in terms of ES usage maturity, they still have to do something to comply with a higher level of ACMM, and (2) If the architecture team of ES adopting organization complies with a higher level (than 3) of ACMM, the ES usage model still has value to offer. This is due to the focus of the ES usage model on the management of ES-supported change and evolveability of the ES.

TABLE 3. SIMILARITIES AND DIFFERENCES BETWEEN ACMMS AND ES USAGE MODELS

ACMMs contain	ES UMMs contain	Both types of models contain
• Definition of standards (incl. frameworks) • Implementation of architecture methods • Scoping in depth & breath of architecture definitions • Planning • Feedback loops based revision • Implementation of metrics program • Responsibility for acquisition • Responsibility for corporate security • Governance	• Managed ES-supported change • Speed of adaptation to changing demand patterns • Responsibility for maintaining stability of information & process environments • Periodic reviews	• Vision • Strategic decision-making, transformation & support • Coherence between big picture view & local project views • Process definition • Alignment of people, processes & applications with goals • Business involvement & buy-in • Drivers

This alone offers significant complementary guidance in the areas of re-focusing resources to better balance the choices between ES rigidity and business flexibility as well as the choice between short-term versus the long term benefits. ES usage models also explicitly account for the role of factors beyond the direct control of the organization. For example, they address the need to stay aware of changes in market demands and take responsibility to maintain a stable environment in the face of rapid change.

VI. Linkages between Architecture Maturity and ES Usage Maturity: Insights from a Case Study

The case company in this study is a Canadian wireless communications services provider who serves both corporate and consumers markets with different subscriber segments in different geographic areas. To maintain the big-picture view of the key business processes and supporting applications while adapting to changing markets, the organization relied on an established architecture team. To support their fast growth, the company also started an ES initiative that included 13 ERP projects within five years. For the purpose of our research, the unit of analysis [11] is the ES-adopting organization. We investigate two aspect of the adopter: (i) the maturity of their architecture function and (ii) the maturity of the ES usage.

A. Architecture Maturity

In 2000, after a series of corporate mergers, the company initiated a strategic planning exercise as part of a major business processes and systems alignment program. A key component of the strategic planning effort was the assessment of architecture maturity and the capability of the organization's architecture process. The DoC ACMM was used among other standards as a foundation and an assessment process was devised based on a series of reviews of (i) the architecture deliverables created for small, mid-sized and large projects, (ii) architecture usage scenarios, (iii) architecture roles, (iv) architecture standards, and (v) architecture process documentation. There are nine unique maturity assessment criteria in the DoC ACMM (as can be seen in the second column in Table 1). These were mapped into the types of architecture deliverables produced and used at the company. The highlights of the assessment are listed below:

Operating unit participation: Since 1996, a business process analyst and a data analyst have been involved in a consistent way in any business (re)-engineering initiative. Process and data modeling were established as functions, they were visible for the business, the business knew about the value the architecture services provided and sought architecture support for their projects. Each core process and each data subject area had a process owner and a data owner. Their sign-off was important for the process of maintaining the repositories of process and data models current.

Business linkage: The architecture deliverables have been completed on behalf of the business, but it was the business who took ownership of these deliverables. The architecture team was the custodian of the resulting architecture deliverables, however, these were maintained and changed based on requests by the business.

Senior management involvement / Governance: All midsized and large projects were strategically important, as the telecommunication industry implies a constant change and a dynamic business environment. The projects were seen as business initiatives rather than IT projects and had strong commitment from top management.

IT investment and acquisition strategy: IT was critical to the company's success and market share. Investments in applications were done as a result of a strategic planning process.

Architecture process: The architecture process was institutionalized as a part of the corporate Project Office. It was documented in terms of key activities and key deliverables. It was supported by means of standards and tools.

Architecture development: All major areas of business, e.g. all core business processes, major portion of the support processes, and all data subject areas were architected according to Martin's methodology [21]. The architecture team had a quite good understanding of which architecture elements were rigid and which were flexible.

Architecture communication: Architecture was communicated by the Project Office Department and by the process owners. The IT team has not been consistently successful in marketing the architecture services. There were ups and downs as poor stakeholder involvement impacted the effectiveness of the architecture team's interventions.

IT security: IT Security was considered as one of the highest corporate priorities. The manager of this function was part of the business, and not of the IT function. He reported directly to Vice-President Business Development.

B. ES Usage Maturity

To assess the ES usage maturity in this case, the ES UMM from Table 2 is used. Assessments were done at two points in time: (i) after the completion of the multi-phase roll-out of the ERP package and (ii) after a major business process and systems alignment initiative run by three merging telecommunication businesses. The first assessment rated the ERP-adopter at Maturity Stage 1, while the second assessment indicated Stage 2. Details on the five assessment criteria are discussed as follows:

Strategic use of IT: The organization started with a strong IT vision, the senior managers were highly committed to the projects. The CFO was responsible for the choice for an enterprise system, and therefore, moving to a new ERP platform was a business decision. The company

also had their CIO in the management team. Assessments of strategically important implementation options were done consistently by the executives themselves. For example, ERP-supported processes were not adopted in all areas because this would have reduced the organization's competitive advantage. Instead, the executive team approved the option to complement the ERP modules with a telecom-business-specific package that supports the competitively important domain of wireless service delivery (including client activations, client care, and rate plan management). This decision was in line with the key priorities of the company, namely, quality of service provisioning and client intimacy.

Organizational Sophistication: Business users wanted to keep processes diverse, however the system pushed them towards process standardization and this led to cultural conflicts. Another problem was the unwillingness to change the organization. People were afraid that the new ways of working were not as easy as before and, therefore, they undermined the process.

Penetration of the ERP system: The amount of involvement of process owners in the implementation led immediately to the same amount of results. The process owners were committed to reuse their old processes, which led to significant customization efforts. The penetration of the ERP can be assessed according to two indicators: the number of people who use the system or the number of processes covered. The latter gives a clearer picture of the use, than the first because many employees can be in functions in which they have nothing to do with the ES. Examples of such functions were field technicians in cell site building and call center representatives. In our case study organization, 30-40% of the business processes are covered with SAP and they are still extending.

Vision: The company wanted to achieve a competitive advantage by implementing ES. Because this was a pricy initiative, they made consistent efforts to maximize the value of ES investments and extend it to non-core activities and back office.

Drivers & Lessons: The company's drivers were: (i) integration of sites and locations, (ii) reducing transaction costs, and (iii) replacement of legacy applications. There was a very high learning curve through the process. Some requirements engineering activities, like requirements prioritization and negotiation went wrong in the first place, but solutions were found during the process. More about the lessons learned in the requirements process can be found in [2].

C. Mapping of the Case Study Finding

This section provides a list of the most important findings from our architecture and ES usage assessment results. Later, in Section 7, this list is compared to the results of our literature survey study (Section 5). The list reports on the following:

1. There appears to be a relationship between the DoC AMM criterion of *Business Linkage* and the ES UMM criterion of *Strategic Use of IT*. Strong business/architecture linkage strengthened the stakeholders' involvement in the ERP initiative: for example, we observed that those business process owners who had collected positive experiences of using architecture deliverables in earlier process automation projects, maintained, in a consistent way, positive attitude towards the architecture-driven ERP implementation projects.

2. There appears to be a relationship between the DoC AMM criterion of *Senior Management Involvement* and the ES UMM criterion of *Vision*. The executive sponsorship for architecture made it easy for the ES adopter to develop the capability to consistently maintain a shared vision throughout all ES projects. Despite that the ES adopter was rated as a Stage 1 organization on the majority of the ES UMM criteria, they managed to maintain at all times a sense of shared vision and identity of who they were and this rated them, regarding the Vision criterion, at Stage 3. This may also be an example of how a mature architecture team can positively influence a Stage 1 organization and help to earlier practice what other ES adopters experience when arriving at Stage 3.

3. Our observations found no correlation between the DoC ACMM criterion of *Architecture Communication* and the ES UMM criterion of *Organizational Sophistication*. At the very first glance, it appeared that the organization was rated low on the *Organizational-Sophistication* criterion of ES UMM due to the low level scored on the *Architecture-Communication* criterion of ACMM. However, a deeper look indicated the *Organizational-Sophistication* criterion got influenced by a number of events over which the architecture team's willingness and efforts to communicate architecture had neither a direct nor an indirect control.

4. There appears to be no relationship between the DoC AMM criterion of *Operating Units Participation* and the ES UMM criterion of *Penetration of the ES*. The ES adopter had designated process and data owners on board in both the architecture process and the ES implementation process. Despite the intuitive belief that a high *Operating Units Participation* positively influences the *Penetration-of-the-ES* rate, we found the contrary be part of the case study reality. Owners of ERP-supported processes could not tie the depth and the breath of ERP usage to architecture. One of the most difficult questions in ERP implementation was how many jobs and job-specific roles would change and how many people would be supposed to work in these roles. This key question is captured in the *Penetration-of-the-ES* criteria of the ES UMM but its resolution was not found based on architecture. Also, both architects and ERP teams saw little correlation between these two aspects.

5. We observed no clear connection between a highly mature *Architecture Process* and the ES UMM criterion of *Drivers and Lessons*. A mature architecture process implies

clarity on what the business drivers for ES initiatives are. In our experience, however, the organization defined business drivers for each project but found later that some of them were in conflict. This led to unnecessary complex ERP customization and needless installation of multiple system versions [2]. However, the ES team did it better in the next series of roll-outs and their improvement was attributed to the role of architecture. Architecture frameworks, architecture-level metrics, and reusable model repositories were made parts of the requirements definition process and were consistently used in the prioritization and negotiation of ERP-customization-requirements in most of the projects that followed. This suggests that an architecture process alone does not determine the project's success but can assist ES adopters in correcting and doing things better the next time.

6. We found no correlation between a highly-mature *Architecture Development* and the ES UMM criterion of *Drivers and Lessons*. In the early projects, the organization failed to see the ES initiative as a learning process. Process owners shared readiness to change their ways of working, but found themselves unprepared to spend time for learning the newly-designed integrated end-to-end processes, the new system, the way it is configured, and the future options being kept open. Inconsistent definitions of business drivers and inconsistent learning from trials and failures favoured a low rating on the *Drivers-and-Lessons* criterion.

7. We found no correlation between a highly-mature *Architecture Development* and the ES UMM criterion of *Organizational Sophistication.* Stakeholders saw process architecture deliverables as tools to communicate their workflow models to other process owners. All agreed that process models made process knowledge explicit. But business users also raised a shared concern about the short life-span of the architecture-compliant ERP process models. Due to the market dynamics in the telecommunication sector, process models had the tendency to get outdated in average each 6 weeks. Modelling turned out to be an expensive exercise and took in average at least 3 days of full-time architect's work and one day of process owner's time. Keeping the models intact was found resource-consuming and business users saw little value in doing this.

To sum up, high architecture maturity does not necessarily imply coordination in determining ES priorities and drivers; neither can it turn an ES initiative into a systematic learning process.

While the architecture maturity in the beginning of the project was very high, the organization could not set up a smooth implementation process for the first six ERP projects. So, at the time of the first assessment, the ES usage maturity was low (stage 1) although the company had clarity on the strategic use of IT and treated the ES implementation projects as business initiatives and not as IT projects.

VII. Comparison with the survey study

This section addresses the question whether the factors identified from our survey study are consistent with the ones identified in our case study. We did this to see if our multi-analyses approach can help uncover subtle information about both the interplay of EA and ES and the research method itself. The factors resulting from the survey and the ones from the case study are compared in Table 4. It indicates a number of overlapping factors in the two case studies: both studies identified four factors that are linked to a mature ES usage and EA. Next, our findings suggest that three factors were identified in the survey but not in the case study. One factor was found in the case study but not in the survey.

Table 4. Consistency check of the findings in the survey and the case study

Factor	Survey Study	Case Study
Vision	yes	yes
Strategic decision-making, transformation & support	yes	yes
Coherence between big picture view & local project views	yes	no
Process definition	yes	yes
Alignment of people, processes & applications with goals	yes	no
Business involvement & buy-in	yes	yes
Drivers	yes	no
Making knowledge explicit	no	yes

VIII. Conclusions

In the past decade, awareness of IT governance in organizations increased and many have also increased their spending in EA and ES with the expectation that these investments will bring improved business results. However, some organizations appear to be more mature than others in how they use EA and ES for their advantage and do get better value out of their spending. This has opened the need to understand what it takes for an organization to be more mature in EA and ES usage and how an organization measures up by using one of the numerous maturity models available in the market. Our study is one attempt to answer this question. We outlined a comparative strategy for researching the multiple facets of a correlation relationship existing between these two types of maturity models, namely for EA and ES. We used a survey study and a case study of one company's ERP experiences in order to get a deeper understanding of how these assessment criteria refer to each other. We found that the two types of maturity models rest on a number of overlapping assessment criteria, however, the interpretation of these criteria in each maturity model can be different. Furthermore, our findings suggest that a well-established architecture function in a company does not imply that there is support for an ES-implementation. This leads to the conclusion that high

architecture maturity does not automatically guarantee high ES usage maturity.

In terms of research methods, our experiences in merging a case study and a literature survey study suggest that a multi-analyses approach is necessary for a deeper understanding of the correlations between architecture and ES usage. The present study shows that a multi-analyses method helps revise our view of maturity to better accommodate the cases of ES and EA from an IT governance perspective and provides rationale for doing so. By applying a multi-analyses approach to this research problem, our study departs from past framework comparison studies. Moreover, this study extends previous research by providing a conceptual basis to explicitly link the assessment criteria of two types of models in terms of symbols, contents and codified good practices. In our case study, we have chosen to use qualitative assessments of EA and ES maturity, instead of determining quantitative maturity measurement according to the models. The nature of the semiotic analysis, however, makes specific descriptions of linkages between EA and ES usage difficult.

Many open and far-reaching questions result from this first exploration. Our initial but not exhaustive list includes the following lines for future research:

1. Apply content analysis methods [23] to selected architecture and ES usage models to check the repeatability of the findings of this research.

2. Analyze how EA is used in managing strategic change. This will be done by carrying out case studies at companies' sites.

3. Refining ES UMM concepts. The ES UMM was developed at the time of the year 2000 ERP boom and certainly needs revisions to reflect the most recent ERP market developments [4].

4. Investigate how capability assessments and maturity advancement are used to achieve IT-business alignment.

Our present results suggest this research is certainly warranted.

REFERENCES

[1] J. Champy, *X-Engineering the Corporation*, Warner Books, New York, 2002.

[2] M. Daneva, "ERP requirements engineering practice: lessons learned", IEEE Software, March/April 2004.

[3] N., Fonstad, D. Robertson, Transforming a Company, Project by Project: The IT Engagement Model, Sloan School of Management, CISR report, WP No363, Sept 2006.

[4] T. Davenport, "The future of enterprise system-enabled organizations", Information Systems Frontiers 2(2), 2000, pp. 163-180.

[5] C. Holland, B. Light, "A stage maturity model for enterprise resource planning systems use", The DATABASE for Advances in Information Systems, 32 (2), 2001, pp. 34–45.

[6] J. Lee, K. Siau, S. Hong, "Enterprise integration with ERP and EAI", Communications of the ACM, 46(2), 2002.

[7] M. Markus, "Paradigm shifts – E-business and business / systems integration", Communications of the AIS, 4(10), 2000.

[8] J. Ross, P.Weill, D. Robertson, *Enterprise Architecture as Strategy: Building a Foundation for Business Execution*, Harvard Business School Press, July 2006.

[9] P. Weill P, J.W. Ross, "How effective is your IT governance? MIT Sloan Research Briefing", March 2005.

[10] Department of Commerce, USA Government: Introduction – IT Architecture Capability Maturity Model, 2003, https://secure.cio.noaa.gov/hpcc/docita/files/acmm_rev1_1_05202003.pdf

[11] L. Dube, G. Pare, "Rigor in information systems positivist research: current practices, trends, and recommendations", MIS Quarterly, 27(4), 2003, pp. 597-635.

[12] R.K. Yin, *Case Study Research, Design and Meth*ods, 3rd ed. Newbury Park, Sage Publications, 2002.

[13] A. Rafaeli, M. Worline, "Organizational symbols and organizational culture", in Ashkenasy & C.P.M. Wilderom (Eds.) International Handbook of Organizational Climate and Culture, 2001, 71-84.

[14] M. Markus, S. Axline, D. Petrie, C. Tanis, "Learning from adopters' experiences with ERP: problems encountered and success achieved", Journal of Information Technology, 15, 2000, pp. 245-265.

[15] Federal Enterprise Architecture Program Management Office, NASCIO, US Government, Available: http://www.feapmo.gov/resources/040427%20EA%20Assessment%20Framework.pdf, April, 2004.

[16] Gartner Architecture Maturity Assessment, Gartner Group Stamford, Connecticut, Nov. 2002.

[17] W. van Grembergen, R. Saull, "Aligning business and information technology through the balanced scorecard at a major Canadian financial group: its status measured with an IT BSC maturity model". Proc.of the 34th Hawaii Int'l Conf. on System Sciences, 2001.

[18] META Architecture Program Maturity Assessment: Findings and Trends, META Group, Stamford, Connecticut, Sept. 2004.

[19] J. Schekkerman, *Enterprise Architecture Score Card*, Institute for Enterprise Architecture Developments, Amersfoort, The Netherlands, 2004.

[20] Ernst & Young LLT: "Are you getting the most from your ERP: an ERP maturity model", Bombay, India, April 2002.

[21] U. Eco, *A Theory of Semiotics*, Bloomington, Indiana, University of Indiana Press, 1996.

[22] J. Martin, *Strategic Data-planning Methodologies*. Prentice Hall, 1982.

[23] N. Fenton, S.L. Pfleeger, *Software Metrics: a Rigorous & Practical Approach*, International Thompson Publ., London, 1996.

[24] S. Stempler, "An overview of content analysis", Journal of Practical Assessment, Research & Evaluation, 7(17), 2001.

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