Integrated Methodology for Information System Change Control Based on Enterprise Architecture Models

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Abstract – The information system (IS) change management and governance, according to the best practices, are defined and described in several international methodologies, standards, and frameworks (ITIL, COBIT, ValIT etc.). These methodologies describe IS change management aspects from the viewpoint of their particular enterprise resource management area. The areas are mainly viewed in a partly isolated environment, and the integration of the existing methodologies is insufficient for providing unified and controlled methodological support for holistic IS change management. In this paper, an integrated change management methodology is introduced. The methodology consists of guidelines for IS change control by integrating the following significant resource management areas – information technology (IT) governance, change management and enterprise architecture (EA) change management. In addition, the methodology includes lists of controls applicable at different phases. The approach is based on re-use and fusion of principles used by related methodologies as well as on empirical observations about typical IS change management mistakes in enterprises.

Keywords – Enterprise architecture (EA), IS change management, IT governance.

I. INTRODUCTION

Enterprise information systems (IS) are subject to frequent modification due to the continuous change of business requirements affected by internal and external factors. The IS change management and governance, according to the best practices, are defined in several standards. Enterprise architecture (EA) provides the basis for strategic level evaluation of the changes in IS [10], [11]. EA frameworks such as TOGAF provide general guidelines for EA change management. Change management is also addressed in other areas of enterprise resource management, for example, project management methods such as PRINCE 2, service management methods such as ITIL, management consultancy methods such as Catalyst, and others. The empirical evidence suggests that enterprises use several methodologies for IS change management, and their integration in enterprise operating model is limited [19], [20]. Each enterprise resource management area is governed separately, usually within different organisation units, and coordination and united oversight are insufficient. That can lead to wasted resources and a duplication of costs and efforts [20].

Lack of integration often leads to insufficient IS change planning and control processes. Failure to comprehend a wider impact of the changes frequently results in sub-optimal architectural decisions having particularly adverse effect on EA [13]. The wrong architectural decisions cause inefficiencies such as poor IS performance, wrong interfaces, bad data quality, doubled data input and sub-optimal IS support to business processes.

One example of insufficient integration is observed in the public sector. Latvian information and communications technology (ICT) policy planners have determined the priorities in the area of ICT for the European Union Structural Funds programming period from 2014–2020 [23]. The systematic approach is developed for public sector ICT development planning according to the envisioned EA model. United mandatory principles, goals and implementation plans are created, though project portfolio management and change control frameworks are partly established. Consequently, the national ICT policy makers currently lack the control mechanism for gaining confidence that different ICT programmes and projects will be implemented in accordance with the envisioned EA. That includes several control aspects, for example, the reuse of existing public sector EA components to avoid development of parallel ICT solutions and the use of mandatory principles of "digital by default" and "digital only".

In this paper, we propose the integrated application architecture change management methodology to address the aforementioned coordination and control problems. The methodology is designed for medium-size and large enterprises, including public sector organisations. Currently, it focuses on application architecture (AA) domain. The aim of the methodology is to provide support to the organisations in the controlled change management environment creation, integrating both IT and EA governance aspects. Expected benefits are reduction of necessary financial and administrative capacity, and improved quality of the solutions.

The rest of the paper is structured as follows. Section 2 provides brief background information and reviews the related works. Section 3 provides an outline of our approach. The paper closes in Section 4 with the conclusions and an outline of future work.

II. RELATED WORKS

A. Related Methodologies

Nowadays, enterprises use several IT management methodologies. IT best practices have become significant due to a number of factors, including business demand on better

returns from IT investments, the need to meet regulatory requirements for IT controls and others [16]. In addition to IT management methodologies, several other enterprise resource management guidelines are used, and they include IS change management recommendations directly or indirectly.

Empirical observations show that organisations most frequently use methodologies in project management, risk management, IT investment management, IT security management and organisational change management areas. The areas are interrelated and often overlap each other, for example, the project management area includes risk and investment management aspects, IT governance area includes IT security aspects etc. Although the mentioned areas are interrelated, several autonomous methodologies are created and used in each of them.

Enterprises have difficulties of implementing and using methodologies. The growth in the use of standards and best practices creates new challenges and demands for implementation guidance, for example, in supporting decision making on which practices to use and how to integrate them with internal policies and procedures [16]. The problem is that there is currently a haze of these standards and companies are not sure which ones to choose and how they fit [17].

IS change management related methodologies and their usage areas are shown in Table I. We have analysed project management, IT governance, EA governance, IT security management, risk management and organisational IT change management areas. Besides, there are several other enterprise resource management areas which we have not analysed in this paper (for example, IT investment management, personnel management and quality management).

TABLE I
IS CHANGE MANAGEMENT RELATED METHODOLOGIES

Methodology /Control area	Project management	IT governance	EA governance	IT security management	Risk management	Change management
ITIL		X				
COBIT		X				
PRINCE2	X					
PMBok	X					
TOGAF			X			
ISO 27001				X		
ISO/IEC 27002				X		
ISO 42010			X			
CMMI					X	
M_o_R					X	
Transform						X
ADKAR						X

Project management methodologies focus on project change management good practice (processes, documentation etc.), for example, in cases when an IT development project includes changes due to "off specification" or changing business needs. IT security management methodologies define security controls that should be considered in change management, while risk management methodologies focus on the risk mitigation actions in change management. Change management methodologies define generic change management phases, processes, and actions.

IT governance best practices, such as ITIL and COBIT, contain guidelines for IS change management in the IT governance context. The ITIL change management process describes standard methods and procedures for implementing changes with a minimum adverse impact on the IT services [14]. The COBIT defines IT change management area controls. ITIL describes process organisation, while COBIT defines controls, i.e., it focuses on what an enterprise needs to do rather than how it needs to do it. The most recent COBIT version (v.5) scope is extended and also includes principles, processes, and IT governance implementation guides. In addition, a separate EA management (EAM) area is included.

EA governance methodologies cover the EA change management related areas. ISO 42010 addresses the creation, analysis and sustainment of system architectures through the use of architecture descriptions. With regard to the IS changes, ISO 42010 includes architecture model development guide that should be used as a basis for review, analysis and evaluation of the system across its life cycle as well as in evaluation of alternative implementation of architecture, also in architecture change cases [15]. The standard suggests establishing criteria for certifying implementations to comply with an architecture. ISO 42010 mainly focuses on application architecture, whereas TOGAF covers several EA domains – application architecture, information architecture, business architecture and technology architecture. TOGAF focuses more on the development of architecture rather than defining architecture reference models. TOGAF architecture development method (ADM) includes the architecture change management phase (Phase H). The objective of Phase H is to establish an architecture change management process for the new enterprise architecture baseline that is achieved with completion of Phase G (Implementation governance phase). The goal of an architecture change management process is to ensure that changes to the architecture are managed in a cohesive and architected way, and to establish and support the implemented enterprise architecture as a dynamic architecture; that is, one having the flexibility to evolve rapidly in response to changes in the technology and business environment [12].

Several IT industry practitioners [16], [17] highlight the problem related to the lack of methodology integration. To address this issue, several guides for integration and implementation of the methodologies have been created [16], [17], [18].

The IT Governance Institute and the Office of Government Commerce have designed and created Aligning CobiT 4.1, ITIL V3 and ISO/IEC 27002 for Business Benefit guide. The guide integrates IT governance and IT security aspects to explain to business users and senior management the value of IT best practices and how harmonisation, implementation and integration of best practices may be made easier [16].

Delton Sylvester [17] proposes the perspective of framework and standard usage (see Fig. 1). However, his recommendations are limited to this picture only.

Fig. 1. The perspective of framework and standard usage proposed by Delton Sylvester [17].

Danny Greefhorst in his white paper [18] provides an overview of EA and TOGAF, and how they relate to COBIT, PRINCE2 and ITIL. The paper shows how TOGAF supports EA, and how it relates to other frameworks in support of the IT processes. It introduces the frameworks and provides an insight into their relationships. The focus is on EA and TOGAF [18]. The paper mainly covers linking aspects of methodologies – the TOGAF is compared with other methodologies to show their relationships. The paper mainly focuses on the EA development process rather than change management.

However, integration guides also do not fully cover the EA management and IT governance integration areas, thus, providing only a partial solution to the aforementioned problems.

B. Related Work

Scientists also note that enterprises struggle with the number of fragmented models, tools and methods proposed to them by multiple disciplines, and the resulting adoption is less than coherent [2]. The problem of methodology integration is highlighted in several research papers, such as [1], [19], [20], [21], where different solutions are also presented.

Article [3] presents a case study in the United States Capitol Police where integrated IT governance, risk management, project (programme) management, investment management and EA management processes are implemented. Processes are based on existing best practices (CMMI, PMI and others) and they are implemented with the aim to reach the enterprise strategic plan. However, the presented case study does not provide clear guidelines and controls that need to be implemented to help enterprises ensure that the changes will be implemented according to the envisioned enterprise strategic goals.

Several research papers investigate the ITIL and EA, especially, TOGAF integration possibilities [19], [20], [21]. In [20], an attempt is made to define the EA specification that uses ITIL principles, methods, processes and concepts to perform IT service management, and general EA principles, methods and models for the design and implementation of the remaining organisational structure. The paper focuses on identification of the elements, properties and relationships of

such an architecture, along with its representation, bringing and placing ITIL elements on the respective EA realms. Article [21] proposes integration by approaching ITIL from an EA perspective and proposes mapping of ITIL concepts to EA, and a set of models representing the ITIL metamodel using the ArchiMate modelling language. In [19], the authors bridge the EA approach and the ITIL framework through the definition of a specific EA for organisations that need to manage IT services. The paper focuses on architecture value by identifying and modelling its valuation concepts and instances.

The main idea of [19], [20], [21] is to use TOGAF for ITIL implementation. These papers focus on the overall implementation and usage of methodologies in enterprises and they do not fully cover specific IS change management needs.

Existing research papers also do not provide a solution to the integrated IS change management in accordance with EA development goals.

III. OUR APPROACH – ICMM

In this paper, we define main phases of our proposed IS change management methodology (further referred to as ICMM). ICMM focuses on high-level recommendations for the IS change management process organisation and applicable controls. It integrates the following enterprise resource management areas – IT governance, EA management and generic organisation change management. ICMM is based on fusion of ITIL, COBIT (IT governance), Transform (change management), TOGAF and ISO 42010 (EA management). The methodology consists of two interrelated parts: 1) guidelines for change management processes and principles that are mainly based on existing methodologies; and 2) control lists. The control lists are designed with the aim to help organisations establish a preventive mechanism for avoiding sub-optimal architectural decisions. We have created controls based on our empirical observations about typical EAM problems at enterprises. The methodology focuses on EA controls and has the same principle as TOGAF ADM Phase H [12]: "An enterprise that already has a change management process in place in a field other than architecture management (for example, in systems development or project management) may well be able to adapt it for use in relation to architecture". In this case, the enterprise can apply the defined controls on its change management processes.

ICMM main phases are shown in Fig. 2. The phases are selected the same way as in the generic change management methodology [23]. The similar process division is used in several change management related methodologies (for example, the Lean Six Sigma and COBIT).

Although we have included five phases, in the context of the IS change evaluation, the first two – assess and design phases are the most important. The change controlling guidelines are elaborated for these phases, for other phases we defined only the applicable controls. Processes in other phases are closely related to the change object and the chosen change development and implementation methodology (for example, Agile vs Waterfall). These development and implementation specific phases will be addressed in the future.

This methodology focuses on significant changes in the AA that can be classified as incremental changes and re-architecting changes according to the TOGAF classification in [12]. Simplification changes are outside the scope, as they do not have a significant impact on EA and they can normally be handled via change management techniques.
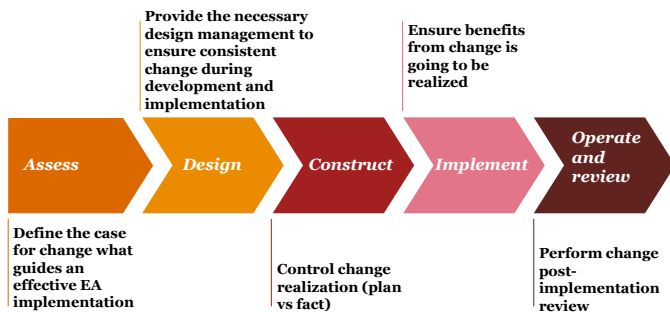

Fig. 2. ICMM phases.

A. Assess Phase

In the assess phase, the case of change and change scope initiatives are created (Fig. 3). The process inputs are request for change (RFC), existing EA model and internal IT governance framework and procedures. The process outputs are authorised RFC and change scope initiatives.
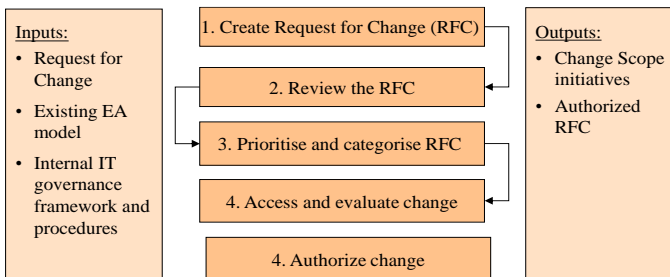

Fig. 3. The outline of assess phase process flow.

The change requestor initialises a change by filling the RFC form. The change manager, IT support service employee or other authorised organisation employees review the RFC, for example, whether there is sufficient information in the RFC for authorisation, and perform preliminary RFC categorisation and prioritisation. The authorised person categorises and prioritises RFC according to organisation internal IT governance metrics. Change advisory board (CAB) or other authorised organisation assesses and evaluates RFC. CAB authorises or declines the change.

ITIL service transition change management process defines the main activities in the assess phase from the IT service management (ITSM) process view. The ITIL change management process describes standard methods and procedures for implementing changes with a minimum adverse impact on the IT services [7].

COBIT Build, Acquire and Implement domain BAI06 (in versions before v5 – BI06) control area recommends controls of the process steps. The area includes change standards and procedures, impact assessment, prioritisation and authorisation,

emergency changes, tracking, reporting, closure, and documentation [4]. Our recommended controls in this phase are stated below.

AC.1. RFC relevance assessment

Assess change case relevance in compliance with the existing EA. Analyse the existing EA and evaluate whether a change implementation goal cannot be met by existing EA components (for example, existing IS functionality). Evaluate if the RFC information is correct in terms of the existing EA model definition (existing taxonomies etc.) and existing constraints (factors that prevent an enterprise from elaborating particular approaches to meet its goals). *Control goal: Prevent from cases when RFC is not relevant, for example, if RFC requestor does not have access or knowledge about existing EA components that can be used to fulfil his needs.*

AC.2. Analysis of EA components and their interoperability influenced by the change

Identify and assess influence on EA components and related business problems and constraints. Analyse existing EA components in all EA views (AA, technical architecture (TA), information architecture (IA) and business architecture (BA)) that potentially will be affected directly or indirectly as well as related business problems. Assess component interoperability (ability to share and exchange the information and services in an effective manner). *Control goal: By change implementation, cover related business needs and concerns (for example, if RFC covers just part of existing business problems).*

AC.3. Change assessment according to development goals (envisioned EA) of the affected EA components

Assess the RFC versus development goals of the change impacted EA components. Identify if change implementation is aligned with development goals and objectives of affected EA components. *Control goal: Ensure that EA changes will lead to envisioned EA development goals and objectives.*

B. Design Phase

In the design phase, envisioned change design is created, including change implementation requirements, principles, target EA after change implementation etc. (Fig. 4). The process inputs are authorised RFC, existing or "as-is" EA model (that is, existing architecture documentation (framework description, architecture description, existing baseline description etc.), envisioned or "to-be" EA model, including architecture principles. The process outputs are project plan, change development technical specification and target architecture.
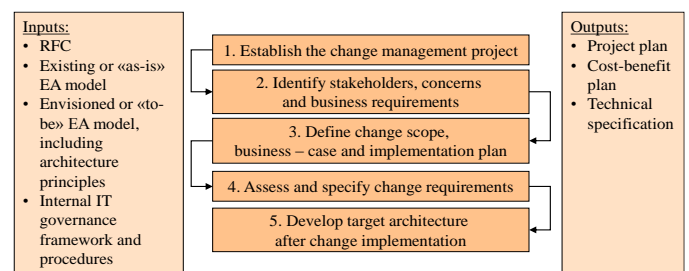

Fig. 4. The outline of design phase process flow.

The change owner or another authorised person establishes the change development project (if applicable) and specifies stakeholders, business requirements and concerns (the key interests that are crucially important to the stakeholders in a system and determine the acceptability of the system). The authorised person defines the change scope, including the cost-benefit case that typically includes: improvement opportunity description, benefits and costs to be offset, implementation costs, technology enablers, people and process enablers, business issues and risk and implementation dependencies. The change scope and business case are developed according to organisation's internal procedures.

The business analyst or another authorised person defines change implementation principles and specifies detailed change functional and non-functional requirements. Afterwards target architecture is created (planned EA after change implementation).

ITIL Service Transition Change management process and COBIT Build, Acquire and Implement domain BAI06 (in versions before v5 - BI06) are also applicable to this phase in the process organisation from the IT management view. ISO 42010 is used for the target architecture model development. Our recommended controls in this phase are stated below.

DC.1. Change assessment in accordance with the envisioned EA implementation principles

Assess the change design documentation (technical specification, target architecture and others) versus the envisioned EA implementation principles. Identify if change implementation is aligned with the envisioned EA implementation principles. The principles are general rules and guidelines, intended to be enduring and rarely amended, that inform and support the way in which an organisation sets about fulfilling its mission (TOGAF, 2011), for example, build vs buy, driven by business requirements vs driven by existing technology, customisation vs standardisation. *Control goal: Ensure that EA changes will lead to the envisioned EA development goals.*

DC.2. Change evaluation according to EA-related lessons learned

Assess the change design documentation (technical specification, target architecture and others) versus previous EA change implementation lessons learned. According to TOGAF (2011), lessons learned can come from anywhere and anyone and cover any aspect of the enterprise architecture at any level (strategic, enterprise architecture definition, transition, or project). *Control goal: Ensure that EA-related mistakes once made are not repeated.*

DC.3. Optimal use of existing re-usable architectural component evaluation

Evaluate whether the change design includes applicable existing EA re-usable architectural components from all EA views (IA, AA, BA and TA), for example, integration platforms, business intelligence tools. *Control goal: Ensure that EA re-usable architectural components are used in the change design for optimal resource allocation.*

DC.4. Design compliance with existing and envisioned EA evaluation

Assess the change design documentation integrity with existing and envisioned EA models. For the existing EA, evaluate semantic and syntactic relevance of components to existing EA components. For the envisioned EA, evaluate design alignment with EA development goals, concerns and constraints. *Control goal: Ensure that EA changes will lead to the envisioned EA development goals.*

DC.5. Change synergy with other planned EA change evaluation

Evaluate change design (requirements etc.) synergy with other ongoing or planned EA changes (for example, other IS development, business process redesign, information standardisation). *Control goal: Ensure that EA changes are not conflicting, overlap each other and lead to the envisioned EA.*

C. Construct Phase

In the construct phase, the change is developed according to the change design. New ways how to operate in all EA domains are technically developed. In this phase, controls regarding architecture changes are performed after the changes are developed and they are mainly focused on the "plan vs fact" control (e.g. developed change is assessed whether it is developed according to the planed change design). From the process perspective, it can significantly differ depending on the change object and applied development methodology. Our recommended controls in this phase are stated below.

CC.1. Assessment of planed and developed solution gaps

Evaluate developed vs planned solution gaps (if during the developed change assessment vs planned change gaps are identified). Gaps should be evaluated according to all aforementioned controls. *Control goal: Ensure that actual EA changes are relevant to current and planned EA.*

D. Implement Phase

In the implement phase, the change is implemented. The phase includes new EA model rollout (including new business processes, applications etc.), as well as assessment that planned benefits are implemented. The implementation phase process is organised according to the implementation plan. Our recommended controls in this phase are stated below.

IC.1. "Go-alive" readiness assessment

Assess the readiness of both technical and business aspects of the change. *Control goal: Ensure that actual EA changes are relevant to current and planned EA.*

E. Operate and Review Phase

In the operate and review phase, the organisation completes "go-live" and executes the cut-over plan to complete all activities required to move from a pre-production environment to live production operation. The phase includes the post-implementation review and the process of lessons learned to allow for problems with the recently delivered increments to be resolved and changes made to the target architectures being designed and planned. After that, the organisation works in a

new way, as well as implements continuous improvement. Our recommended controls in this phase are stated below.

OC.1. Post-implementation review

Conduct the post-implementation review to assess if the planned benefits are gained, identify lessons learned and opportunities for improvement. *Control goal: Ensure that benefits from change are implemented.*

IV. Conclusion and Future Work

This paper has outlined an integrated change management methodology. The methodology consists of guidelines for IS change control by integrating the following significant resource management areas – IT governance, change management and EA change management. In addition, the methodology includes lists of controls applicable at different phases. The approach is based on re-use and fusion of principles used by related methodologies as well as on empirical observations about typical IS change management mistakes in enterprises.

The methodology provides an overall framework for elaboration of IS change management methods. The method will combine both theoretical foundations and a practical tool that will be used in the IS change management support. The theoretical foundation will be designed for the IS change managers, enterprise architects and other roles responsible for IS change management processes optimisation and integration with EA governance. In contrast, the tool will focus on the end user (change requestor) needs. The tool will increase the usability of IS change management support systems by providing users with EA model information for change request filling support. Planned tool implementation benefits are reduced filling and processing time of change requests.

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