SCOR-based enterprise architecture methodology

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Increasing competition and fast changes in markets require more enterprise agility and adaptability. Enterprises have to evolve continuously to attract customers and ensure sustainability. In fact, organisations of all sectors are facing two main challenges: (i) Better understanding of enterprise structures and (ii) Aligning information technologies with business strategies. These challenges are faced by all manufacturing organisations whether they are global companies or small enterprises. Many research activities have been carried out by the scientific community in order to develop and improve enterprise modelling frameworks. Zachman (1987) specified a framework to represent enterprises according to different points of view. It was the first enterprise Architecture Framework. Since 1987, researchers and experts have proposed several Enterprise Architecture frameworks for military (Chief Information Officer Council, 2001) or for manufacturing organisations (Lapkin A., 2005). Existing Enterprise Architecture frameworks share a set of steps such as analysing current architectures, modelling future architectures and identifying ways to reach this future state. But they don’t provide a step by step methodology that goes from identifying enterprise business strategies till process flow analysis and improvements. Besides, supply chain analysis is a success key factor that is often missing in Enterprise Architecture frameworks despite its significance. Here, a multi-level enterprise architecture methodology (S-Beam) is proposed to guide decisions of improvement at both strategic and operational levels. The methodology is intended to provide a global vision of supply chain and to improve its performance. In the present study, we begin by researching enterprise architecture literature, and then we present the proposed methodology. A case study of this methodology application will also be carried out.

Keywords: enterprise architecture; supply chain management; SCOR; business capabilities

1. Introduction and problem definition

Increasing competition and fast changes in markets require more enterprise agility and adaptability (Rohloff 2005). Companies have to evolve continuously to attract customers and ensure sustainability. A permanent process of operations improvement needs to be maintained and updated regularly to take into account environmental changes. Organisations of all sectors are facing two main challenges: (i) Better understanding of their enterprises’ structures and (ii) Aligning information technologies with business strategies (Harding and Popplewell 2010, Cuenca et al. 2011). These challenges are faced by all manufacturing organisations whether they are global corporations or small enterprises. In fact, conducting changes require modelling and analysis of current structure of enterprise and must be carried out according to enterprise strategies. Therefore, enterprise’s resources – in particular IT resources – need to be aligned with business stakes to keep moving towards strategic goals. Lots of research activities have been carried out by the scientific community in order to develop and improve enterprise modelling frameworks. Zachman (1987) specified first ever an Enterprise Architecture Framework to represent enterprises according to different points of view. Since 1987, researchers and experts have proposed several Enterprise Architecture frameworks for the military (Chief Information Officer Council 2001) or for manufacturing organisations (Lapkin 2005). Existing Enterprise Architecture frameworks share a set of steps such as analysing current architectures, modelling future architectures and identifying ways to reach this future state. But they don’t provide a step by step methodology that goes from identifying enterprise business strategies till process flow analysis and improvements. Besides, supply chain analysis is a success key factor that is often missing in Enterprise Architecture frameworks despite its significance. Here, a multi-level enterprise architecture methodology is established. It provides a framework for IT alignment with strategic stakes. The methodology is intended to support supply chain modelling, analysis and
optimisation. An investigation of enterprise architecture literature is presented in order to analyse existing approaches and models in section II. Section III summarises these approaches assessments. In section IV the proposed methodology concepts and phases are described. Section V is dedicated to the methodology deployment impact.

2. Literature review

The concept of ‘Enterprise Architecture’ was introduced by Zachman (1987). He assumed that a logical construction is needed to encounter the complexity of information systems. Zachman created an architectural framework that can comprise a set of architectural representations of organisation processes or activities (Zachman 1987). Zachman’s Framework is a two dimensional classification for descriptive representations of an enterprise. The designed artefacts are classified by the audience for which they were constructed (i.e. Perspective), and by the subject focus of the artefact (i.e. Abstraction) (Zachman 2003). This multi perspective vision helps to convince the actors of the enterprise with their different process interests. Nevertheless, Zachman does not give a step-by-step process for creating a new architecture (Sessions 2007). His framework is rather taxonomy of the Enterprise Architecture processes. In the 1990s, the ESPRIT consortium AMICE (1989, 1991, Kosanke 1995) developed an enterprise architecture Framework called CIMOSA (Computer Integrated Manufacturing Open System Architecture). It is aimed at process-based enterprise engineering concepts and tools (Bernus and Gransier 1995). The modelling framework and an integrating infrastructure (IFIP-IFAC, 1994; Santos et al. 2000). The concept of ‘Enterprise Architecture’ was introduced by Zachman (1987). He assumed that a logical construction is needed to encounter the complexity of information systems. Zachman created an architectural framework that can comprise a set of architectural representations of organisation processes or activities (Zachman 1987). Zachman’s Framework is a two dimensional classification for descriptive representations of an enterprise. The designed artefacts are classified by the audience for which they were constructed (i.e. Perspective), and by the subject focus of the artefact (i.e. Abstraction) (Zachman 2003). This multi perspective vision helps to convince the actors of the enterprise with their different process interests. Nevertheless, Zachman does not give a step-by-step process for creating a new architecture (Sessions 2007). His framework is rather taxonomy of the Enterprise Architecture processes. In the 1990s, the ESPRIT consortium AMICE (1989, 1991, Kosanke 1995) developed an enterprise architecture Framework called CIMOSA (Computer Integrated Manufacturing Open System Architecture). It is aimed at process-based enterprise modelling and enabling these models at operational level. CIMOSA architecture consists of a modelling framework and an integrating infrastructure (Zwegers and Gransier 1995). The modelling framework is based on three dimensions namely, genericity, enterprise models and views. Genericity dimension goes from generic building blocks to specific enterprise domains models. Enterprise models dimension supports enterprise operations lifecycles and ranges from requirements definition to system implementation. Finally, the view dimension provides different views to business user offering him reduced complexity of his area of concern (Kosanke 1995, Zwegers et al. 1997). Another Enterprise Architecture Framework was proposed during the 1990s. It is The Open Group Architecture Framework TOGAF (Open Group 2003). TOGAF has been improved by representatives of different leading IT organisations from all over the world. According to TOGAF, Enterprise Architecture encompasses four categories of architecture; Business, Applications, Data and Technical Architecture. TOGAF considers Enterprise Architecture as a continuum of architectures ranging from highly generic to highly specific. Creating any specific architecture is equivalent to moving from the generic to specific (Sessions 2007). TOGAF Architecture Development Method is based on the following layers: Business architecture, information system architecture, technology architecture, solutions, migration and change management. TOGAF allows its steps to be skipped or to be done incompletely. It is flexible regarding the methodology processes achievement; accordingly the resulting architecture is not necessarily better than the present structure. In 1998, the Chief Information Officers Council (1999) released the first version of Federal Enterprise Architecture Framework. The FEA Framework consists of a set of interrelated reference models that allow identifying gaps and opportunities for collaboration within the Federal agencies (Federal Enterprise Architecture Management Office 2007).

Reference models, in their 2.3 version, are ordered according to a business-driven approach as follows (Sessions 2007):

1. Performance Reference Model: defines ways to describe value delivered by Architecture
3. Service Components Model: gives more IT view of the system.
4. Data Reference Model: defines standard way to describe data.
5. Technical Reference Model: defines technologies that can be used to build IT systems.

Collectively, the reference models comprise the Framework that describes the Federal operations effectively and in a common way (Federal Enterprise Architecture Management Office 2007). This Framework seems to be interesting beyond the public sector since the reference models can be adapted to any particular organisation. A more generic enterprise architecture framework was proposed in the late 1990s by the IFIP-IFAC task force (IFIP-IFAC 1994). The task force members recognised that a generic enterprise modelling framework is needed to improve enterprise integration. The outcome of their work was the Generalised Enterprise Reference Architecture and Methodology (GERAM). GERAM is a generic enterprise architecture framework based on Williams (1994), Doumeingts (1987), Kosanke (1995) and Zwegers et al. (1997). It provides a set of requirements to unify different tools of enterprise integration (IFIP-IFAC, 1994; Santos et al. 2000). The GERAM reference framework is comprised of a generic reference framework, enterprise engineering methodology and enterprise models. It also provides enterprise engineering concepts and tools (Bernus and
Nemes 1997). Later on, in 2003, the Department of Defense of the United States proposed DoDAF Framework (Kobryn and Sibbald 2004). The 2.02 version of DoDAF, released in 2010, is based on a set of models describing an organisation according to eight views, namely, All Viewpoint, Capability, Data and Information, Operational, Project, Services, Standards and Systems viewpoints. The All Viewpoint viewpoints describe the overarching aspects of the architecture context that relate to all viewpoints. Capability Viewpoint focuses on capability deployment. Data and Information Viewpoint describes the data structures and relationships for the capability, processes and services and systems. Operational Viewpoint includes the operational scenarios, activities, and requirements that support capabilities. Project Viewpoint describes the relationships between operational and capability requirements and the various projects being implemented. Service Viewpoint describes solutions for or supporting operational and capability functions. Standards Viewpoint articulates the applicable operational, business, technical, and industry policies, standards, guidance, constraints, and forecasts that apply to capability and operational requirements, system engineering processes, and systems and services. Finally, the Systems Viewpoint is the design for solutions articulating the systems, their composition, interconnectivity, and context (Department of Defense 2011). Two years later, a new Enterprise Architecture Framework was proposed by Gartner (Lapkin 2005) that provided a synthesis of best practices to develop and maintain an organisation’s Enterprise Architecture (Bittler et al. 2005). Its process encompasses governance and managing as a bridge between the current State-Architecture and the future State-Architecture. The transformation is carried out according to Environmental Trends as well as Enterprise Business Strategies. Enterprise Architecture to the Gartner view consists of three components: business owners, information specialists and technology implementers. Thus, the enterprise architecture is ‘about strategy, not about engineering’ (Sessions 2007). Gartner provides a set of practices rather than a mere Enterprise Architecture methodology; it focuses mainly on strategic stakes and does not involve the technical level. In the same year Rohloff (2005) proposed an Enterprise Architecture Framework based on common blocks of an Enterprise Architecture: Business, Applications and Infrastructure architectures. Rohloff (2005) synthesised Enterprise Architecture concepts in a common framework. He referred to Zachman (1987) taxonomy to develop a methodology for Enterprise Architecture. The British Ministry of Defense (MOD) proposed a framework to develop an Enterprise Architecture called MODAF (MOD Architectural Framework) in the 2005. MODAF consists of six viewpoints namely, Strategic, Operational, Service, System, Standards and Acquisition viewpoints. Strategic viewpoint consists of documenting the strategic picture of how capability supports management and equipment planning. Operational and System viewpoints document operational processes and system functionalities, respectively. Service viewpoints describe what the enterprise shall do (Ministry of Defense 2005, 2011, Bailey 2008). The two last viewpoints ensure support for the architecture process, which revolves around use and scope definition, capturing architecture, analysis and documentation. A major Architecture Framework commonly used in the military field is the North Atlantic Treaty Organisation (NATO) Architecture Framework (NAF). NAF capitalises on both DoDAF and MODAF knowledge and other experiences from different fields. Its third version utilises four types of architectures: Overarching Architecture, Reference Architecture, Target Architecture and Baseline Architecture. Overarching Architecture is a general description of the future situation. A more detailed description is provided by the Reference Architecture. The Target Architecture addresses the implementation decisions. The Baseline Architecture provides information about the as–is state. NAF views are a mix of different experience outcomes. It inherits the All Viewpoint viewpoint from first versions of MODAF. NAF also shares the Service-Oriented, System and Operational viewpoints with MODAF. In addition to the Technical View, also used in DoDAF, NAF uses the Programme View (NAO 2007). More recently, the Open Management Group (2010) proposed a Unified Profile for DoDAF and MODAF in order to enable practitioners to express these two frameworks elements and organise them in a set of viewpoints, namely, Strategic, Acquisition, Operational, Technical, Systems, All Views and Custom views. UPDM species two compliance levels to UML2 and SysML. A recent survey on enterprise engineering standards at large, can be found in (Chen and Vernadat 2011).

3. Enterprise architecture frameworks assessment
The assessment of the investigated Architecture Frameworks requires several criteria coming from the context of the study. Several criteria may be found in literature, such as the ones of Sessions (2007). The criteria themselves are quite objective but not all of them are relevant to all organisations. Furthermore, the ranking process of an Architecture Framework is very subjective and also depends on the goal of modelling. Thus, instead of using extant criteria, another method is used in this section. It consists of
identifying the improvement areas with regards to the context of the current article. Then, a set of criteria are established, and finally investigated Architecture Frameworks are evaluated. It is noteworthy that the analysis carried out in this section is focused on some specific aspects such as supply chain focus and architecture method. To point out the main issues related to extant Architecture Frameworks, their scopes and methods were analysed. As mentioned earlier in the article, supply chain vision needs to be considered within an Enterprise Architecture due to its strong link with the enterprise. In fact, enterprises have an impact on supply chain and vice versa. Furthermore, process vision is a key element of any enterprise architecture framework. The process layer is a fundamental component that depicts enterprise operations in a set of standardised units. Strategic alignment is one of the key issues addressed by Enterprise Architecture Frameworks; hence it needs to be considered within the current assessment. In addition to the above-mentioned elements, an Enterprise Framework Architecture needs a method to support its use and guides practitioners through a well-defined process, thus improving reusability. As a consequence, the criteria used for the evaluation are the following: Supply Chain Focus (SC focus), Process Focus, Strategic Alignment (Str. alignment) and Method clarity (Method).

The comparison depicted in Table 1 shows obviously that supply chain is often out of the existing frameworks scope (i.e. Zachman, TOGAF, etc.). Some of these frameworks defined Enterprise Architecture methods (i.e. MODAF, DoDAF, CIMOSA . . .) and some others focused on guidelines to enhance strategic alignment (i.e. Gartner, NAF). GERAM and NAF seem to satisfy most of the criteria. Nevertheless, GERAM is generic framework and its proposed method is not supply chain oriented. The completeness of NAF makes its deployment harder. To summarise, strategic alignment process is an ambitious goal to be achieved by enterprise architecture. Thus, it needs to be considered within the architecture process. The Enterprise Architecture Framework is meant to provide the method for achieving such a goal; hence the method clarity is essential. Furthermore, the modelling of enterprise according to different views (Process, Data and Information, etc . . .) is not always enough to conduct global change, thus supply chain vision is needed to address such issue. A convenient Architecture Framework (with regards to the current article context) needs to satisfy all the criteria above mentioned. In the next section, an Enterprise Architecture method, involving strategic alignment and supply chain improvement is presented. The proposed method is meant to bridge the gap between strategic and operational levels in the supply chain.

4. Proposed framework

4.1. Framework principles and tools

The framework is based on a top down methodology that aims to carry out global change in organisations and particularly in their supply chains. The methodology uses several concepts and some of Gartner tools and focuses mainly on functional and applications architectures. In addition to Gartner tools and business capabilities, the methodology uses the Supply Chain Operations Reference (SCOR) (Supply Chain Council 2010) which is widely used by both academics and practitioners in the field of supply chain management and performance improvement. SCOR model is described in detail in the following.

4.2. Supply Chain Operations Reference (SCOR)

SCOR was proposed by the Supply Chain Council with the aim of improving supply chain performance. It was meant to help refine strategy, manage processes and measure performance. The model contains performance multi level metrics, processes and practices. The multi level metrics are grouped into several categories and used to express strategies. The processes identified by SCOR are the ones required to fulfill customer orders. They are also organised by aggregation and decomposition. First level, the more generic one, includes Plan, Resource, Make, Deliver and Return (Figure 1). Processes configurations (i.e., Make-to-Stock, Deliver-to-order . . .) are defined at level 2. Level 3 processes describe the steps to be performed to execute the level 2 processes. Level 4 and above describe the company’s specific activities (Supply Chain Council 2010). As shown in Figure 1, the supply chain can be depicted in a standard way using the aforementioned processes. To ensure a more efficient management of the processes, SCOR provides

<table>
<thead>
<tr>
<th>Framework</th>
<th>SC focus</th>
<th>Process focus</th>
<th>Str. alignment</th>
<th>Method</th>
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<tbody>
<tr>
<td>Zachman</td>
<td>X</td>
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<tr>
<td>CIMOSA</td>
<td>X</td>
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<td>GERAM</td>
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<td>TOGAF</td>
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<td>FEA</td>
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<tr>
<td>DoDAF</td>
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<td>Gartner</td>
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<td>Rohloff</td>
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<td>MODAF</td>
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<td>NAF</td>
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<td>UPDM</td>
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Note: X: high degree of focus; \: low degree of focus.
a set of best practices which are unique ways to configure a process or a set of processes. Several green practices and strategic metrics have also been introduced in the model resulting in the GreenSCOR. In addition to the environmental considerations, the 10.0 version of SCOR released in June 2010 incorporates a standard to describe skills required to perform tasks and manage processes.

In parallel with SCOR development and improvement, other models were also developed in compliance with SCOR structure but for quite different purposes. The Design Chain Operations Reference Model version 1.0 released by the SCC in 2006, was meant to support design chains of various complexities (Supply Chain Council 2006). Some SCOR preliminary models were also developed in order to be used in Enterprise Architecture Software such as Architecture of Integrated Information Systems (ARIS) and The Information Bus Company (TIBCO) Business Studio. This allows companies to efficiently design, evaluate and improve supply chain processes. In the current work, TIBCO Business is used for the case study modelling.

4.3. Methodology phases

Conducting global change requires focus on enterprise strategies, which are strongly linked to environmental trends. Thus, the first phase of the proposed methodology is aligning IT to business needs (IT Alignment) by the use of the Gartner matrix. Studied supply chain structures, business capabilities and its related Environmental Trends are the main inputs of phase 1, though other inputs are involved (i.e. Business Requirements, IT Requirements, etc.). A Goals Model is build upon the requirements specified in phase 1. This Model is actually the input of phase 2 where the as–is state of the supply chain is analysed, thus supply chain structure and business capabilities are also an input of phase 2. At the end of phase 2, a set of indicators and Functional and Technical Specifications are established. The indicators provide information about the current state of the supply chain (i.e. identification of resources and supply chain references used within the company) and helps building the target architecture. Guidelines for the latter are provided by the aforementioned specifications. After getting a clear idea about the as–is state, we focus on the target model details progressively. Phase 3 uses supply chain structure and business capabilities as an input. The effort carried out during this phase is crowned by the supply chain Reference Model (based on SCOR and the Business Capabilities Map) as well as the generic modelling (i.e. Level 1) of Functional and Application Architectures. The latter two are further developed with more detail in phase 4, where their sublevels are modelled (i.e. Level 2). It is noteworthy that modelling carried out in phase 4 may suggest updates of the target architecture level 1 in some cases (i.e. modification of several sub-processes that induces changes in level 1 architectures). This is depicted by the loop between phase 3 and 4. The final phase (i.e. phase 5) to be undertaken is the optimisation of processes and applications. In addition to Functional and Application Architectures defined previously, supply chain resource requirements are needed to provide Improved Processes and Applications. A loop takes place at this level and enables the update of Functional and Applications architectures whenever a specific activity/process is optimised in phase 5 (this will be more obvious through the case study). Methodology phases are depicted in Figure 2.

4.3.1. Phase 1: IT alignment

Business processes efficiency is strongly linked to the information technology within a firm. Consequently, strategic business and IT alignment becomes a crucial task and one of the top concerns of the Chief Information Officer in an enterprise (Silva et al. 2006). In this context, Peyret (2009) admits that enterprise architects must collaborate with business process professionals, data managers and IT stakeholders.

The Gartner Matrix (Lapkin 2005) is an efficient tool for the IT alignment with business strategies. Before using the matrix, we should identify firm’s “Environmental Trends”. Environmental trends may be of different types (e.g. new technologies, etc...) but

Figure 1. SCOR Top Level Processes.
they are often related to the firms market. For a piping solution enterprise, whose customers are petroleum companies, new reservoir challenges such as resource depletions and new emerging applications are environmental trends that will require more sophisticated products adapted to new functional conditions. The complexity of the tubular products’ markets is also a trend (and challenge) for the supply chains.

We map Enterprise Business Strategies to Environmental Trends, Business Information Requirements to Enterprise Business Strategies and Information Technology Requirements to Business Information Requirements. After each mapping, a prioritisation task is performed in order to determine the most relevant factors among all the ones identified (Figure 3). As a consequence, the goals established at the end of the IT alignment consists of potential IT improvement alternatives.

4.3.2. Phase 2: As-Is analysis

The goal of this phase is to depict the current enterprise structure in a model that gives a global view. Such a model allows faster diagnostics and more efficient end-to-end process analysis. To achieve this step, we refer to the capability map. The proposed methodology is supply chain oriented, thus this phase is based not only on identifying gaps between current enterprise processes and the business capabilities
reference framework, but also on defining the level of SCOR integration. Here are main indicators identifying issues in this phase:

1. SCOR and Business Capability models convergence: identifies how many business capabilities can be mapped to SCOR to describe supply chain processes.
2. Business Capabilities integration: identifies the level to which business capabilities are used in enterprise reference models.
3. SCOR integration: identifies the level to which SCOR is integrated in the enterprise supply chain.
4. Applications efficiency: this point is analysed through a matrix of applications and processes. It reveals information systems problems such as duplication and non-coverage of processes.

4.3.3. Phase 3: Target top level

The goal of this phase is to model the future shape of the supply chain processes and/or applications. Here, a new model is proposed based on business capabilities and the SCOR model. Such a model provides a global vision of Enterprise resources and allows analysing and improving supply chain performance. In fact, Business capabilities provide taxonomies of enterprises capabilities. The SCOR model is an efficient tool for supply chain modelling and analysis. It categorises all supply chain activities in the primary processes: Plan, Source, Make, Deliver and Return. Using both of the two models helps to bridge the gap between the Enterprise Architecture and business process modelling. A mapping between SCOR processes and business capabilities is providing a new supply chain reference model. The process of defining such a model is based on the following steps:

- Selection of a reference business capabilities model adapted to the company: The business capabilities depend on the sector, thus, for each company this step is crucial. The one used within the company where the case study is carried out is the High Performance Business Process (HPBP). HPBP is a business process reference in the company’s sector established by a global management consulting, technology services and outsourcing company. It includes the high level processes for the enterprise.
- Mapping SCOR high level processes to the Capability areas of the HPBP: This requires analysis of the capability areas (definitions, taxonomy) as well as of SCOR processes in order to determine the complementarities.
- Mapping SCOR high level processes to business capabilities of the HPBP: Once complementarities are identified, SCOR high level processes are mapped to the business capabilities. This step is actually the extension of the previous one which serves in turn, to narrow the scope of the mapping.
- Mapping SCOR sub-processes to business capabilities: There is not a one-to-one mapping between SCOR sub-processes and the HPBP business capabilities, hence a more detailed analysis is required in order to refine the previous mapping. This provides a part of the target top level.

Figure 4 shows a part of the reference model based on both SCOR and HPBP. The model has already been exploited by the company by integrating it in the current enterprise architecture models. In the Figure, process ‘Plan’ is mapped to a set of business capabilities from the HPBP according to the aforementioned steps. The mapping of all SCOR processes to the HPBP model provided a complete reference model for the supply chain that includes two well-known references, namely SCOR and HPBP. The IT team of the company is likely to add a supply chain view to the set of view already developed, but this is yet under study.

4.3.4. Phase 4: Target sublevels

Business Process Modelling is actually the core of this phase. The goal is to describe the firm’s processes in compliance with SCOR processes. The starting point is
the phase 3 output. SCOR offers the possibility to model progressively the enterprise functionality through multi level modelling. The SCOR standard processes are limited to the first three generic (i.e. top) levels. Level 4 and above depend on the company processes, activities, etc. Thus, we need to model the fourth and all the higher levels according to the firm’s specific processes. As shown in Figure 5, the top level modelling is carried out in phase 3. Process configurations are defined in a configuration modelling level during phase 4. Possible configurations for a process ‘p’ are for example p-to-order, p-to-stock . . . At Process Element Level, we focus on sub-processes. Then, we model activities and tasks, which are specific to each organisation structure.

4.3.5. Phase 5: Optimisation

SCOR provides an adequate framework for process modelling and analysis. It helps identifying improvement opportunities among supply chain processes. To address problems defined in phase 4, optimising approaches are required. These approaches must be the continuation of SCOR optimising work. Kent et al. (2007) have analysed complementarities among SCOR, Lean and Six Sigma. They consider that ‘Lean and Six Sigma complement and strengthen the SCOR-based strategic decisions by providing a continuous improvement philosophy’. Sealing (2009) considers that convergence lies in the fact that SCOR allows to identify improvement opportunities, Six Sigma provides problem solving methodologies and Lean techniques contribute to the elimination of waste. Pettersen (2009) has carried out a review of lean production literature and investigated its associated characteristics such as small lot production, pull system, lead time reduction and inventory reduction. Based on an affinity analysis, he grouped these characteristics into nine families (e.g. just in time practices, resource reduction, Human relations management, supply chain management . . .). Such a classification could be useful in this phase since it provides more guidance during the optimisation. In fact, the optimising technique to be adopted here is chosen according to both the improvement opportunities identified in phase 4 and Petersen’s taxonomy of lean associated practices. First, such criteria provide information about problem location and size (i.e. in which process of the supply chain); second, such criteria will guide the choice of the most appropriate tools to address the problem. The idea of coupling the modelling and the optimisation is quite consistent with the approach advocated by Vallejo et al. (2011) who attempted to integrate several enterprise modelling tools in a holistic framework for enterprise performance improvement.

4.4. Conceptual model

Figure 6 describes the methods and tools comprising the S-BEAM framework. The latter is comprised of a method and several tools. The method is based on the five steps described above; namely, IT Alignment, As–Is Analysis, Target Top Level Modelling, Target Sub-Levels Modelling and finally Optimisation. The third and fourth steps comprise the Target Architecture, which is compliant with the Reference which is built upon the Business Capabilities Map and SCOR. The Reference as well as the Gartner Matrix are the Tools used within the framework. The Gartner Matrix is useful for the first step of the S-BEAM Method namely, IT Alignment. The conceptual model of Figure 6 is process oriented; it focuses on the methodology and tools used rather than the product (i.e. Supply chain, etc.).

5. S-BEAM application

5.1. Methodology deployment

The case study is on a world leader in its sector. The development and application of the method has been carried out within a two-year project that aimed to improve supply chains performance and the company’s information systems efficiency while rationalising enterprise architecture culture. The former includes but is not limited to enhancing information system sharing and reducing its complexity and redundancy. The latter involves all aspects of communication and integration of enterprise architecture practices at all parts of the enterprise hierarchy. Mainly involved are IT and supply chain teams. The studied supply chain includes nine plants performing three different operations. General goals were aligning IT with business, carrying out global change and improving supply...
chain performance. After specifying goals, existing architectures were analysed. Based on the as–is diagnosis, the SCOR model and Business capability levels of integration were also identified. These aspects were measured through a set of indicators, I1, I2, I3 and I4. The first three indicators are quantitative and the last one is qualitative. I1 measures SCOR and HPBP crossings, it describes how many business capabilities can be mapped to SCOR. I2 measures HPBP Business Capabilities integration, it shows to which level are enterprise processes organised around business capabilities. I3 measures SCOR integration, it refers to which level is SCOR integrated in enterprise supply chain. I4 allows evaluating Application efficiency through a matrix of applications and processes. It reveals information system problems such as duplication and non-coverage of processes. Results of I1, I2 and I3 calculation for the case study are shown in Figures 7–9, respectively. Almost 75% of HPBP is useful for the supply chain modelling and improvement. This also fosters SCOR implementation within the company’s supply chain since it has already begun to use HPBP as a reference. The second indicator shows that less than 40% of HPBP are already taken into account by the company which requires more use of such a reference. In terms of

Figure 6. S-Beam conceptual model.

Figure 7. I1: HPBP and SCOR crossings.
SCOR use, almost 50% of the overall reference is already supported by the ERP system (SAP) in the company.

The outputs of ‘IT alignment’ and ‘As–Is analysis’ phases provided the basis for the establishment of several recommendations classified in two families: functional and technical.

- **Functional architecture:**
  - Improve standardisation in the supply chain processes.
  - Integrate business capabilities reference by providing a supply chain reference model based on business capabilities and SCOR model.
  - Provide metrics to analyse supply chain performance and benchmark its indicators with competitors.
  - Provide a tool to assess Enterprise Architecture Maturity level.

- **Technical architecture:**
  - Ensure more interoperability between applications through deploying standard ERP solutions.
  - Reduce the number of specific applications.
  - Build centralised data bases and repositories.

Afterwards, SCOR processes were mapped to business capabilities in order to get a new reference model to be used in supply chain optimisation (the model is briefly described in the previous section). Such a model satisfies most of the requirements specified previously in (i) and (ii). After defining the reference model, SCOR second and third modelling levels were performed using TIBCO software for business process modelling. SCOR Levels 1 to 3 are standard but very useful for the supply chain modelling since they provide a structured way to depict processes. Such modelling provides a clear vision of the supply chain processes and helps highlighting process issues. Based on discussion and meetings with supply chain and IT staff, we agreed to focus initially on planning related issues. Hence, the modelling level deals with SCOR Plan sub-processes. Figure 10 depicts the Plan Supply Chain process. The process to be investigated at first is ‘Balance Supply Chain Resource with Requirements’. Thus, SCOR level 4, which is more specific to the company and in particular to the studied supply chain, was also modelled and the analysis was narrowed to some specific supply chain planning issues. The challenges to be dealt with at this level are first, to foster the Quota Management Process by improving results reliability and reducing the process time. Second issue is to ensure more efficiency in the production split over the supply chain plants in a way to keep cost as low as possible and to meet customer demand with the required quality. The first issue has been addressed in phase 4 where a modified Quota 1 Management process was proposed. Figures 11 and 12 show the Quota Management before and after improvement, respectively.

As shown in Figure 11, the user (Supply Chain Manager) had to change manually quota values since in the old version of the software used for that purpose capacities and constraints are not well defined. In Figure 12, a systematic process allows the Quota calculation while respecting capacity constraints and thereby allowing the automation of the whole process. The second issue is addressed in phase 5 namely Optimisation. Linear programming was adopted as a first alternative to ensure a better plant quota distribution while reducing costs and lead times. The optimisation method, already applied to a small sample, has proven to be effective. Thus, the optimisation phase also provided useful output for the supply chain manager who is interested in this improvement. The software for the quota management is actually being improved and quota calculation methods are being modified. The use of the software will be extended to the other supply chain divisions.

**5.2. Long term benefits**

The Methodology long term benefit assessment is based on Nascio (2003). He proposed an Enterprise...
Architecture Maturity Model based on a set of best practices. Maturity Levels range from 1 to 5 and depend on best practices integration levels. The Nascio model is used to assess excepted level of maturity after applying S-BEAM. Such a level could be reached within several months. To ensure achievement of such a goal, trainings need to be planned in order to improve the staff knowledge about Enterprise Architecture. The Enterprise Architecture Maturity Model is shown in Figure 13. Light grey denotes Maturity level before deploying the methodology. Dark grey denotes Maturity level after applying the methodology.

1) Administration: The need for Enterprise Architecture Governance has been identified and Governance Committees are starting to form.

2) Planning: Enterprise Architecture programmes will be developed according to a well-defined methodology.
Framework: Enterprise Architects will be able to reuse methods for different projects of Enterprise Architecture.

Blueprint: Documentation of business capabilities and supply chain processes is being performed.

Communication: The need for Enterprise Architecture is being communicated to senior Management and Enterprise Architecture awareness activities are beginning to emerge and develop.

Compliance: Use of references; SCOR and HPBP (expected).

Integration: Touch-point with management processes (i.e. the optimisation phase in phase 5 of S-BEAM) (expected).

Involvement: Increase awareness about the need to an EA Framework adapted to the company’s supply chain (expected) (Figure 13).

One of the major contributions of the enterprise maturity model is the enhancement of business capabilities and processes documentation (i.e. Blueprint), this was one of the project aims. The proposed method which comprised five ordered phases boosts the Planning and Framework practices. The use of known references (i.e. SCOR, HPBP) offered the methodology more Compliance and highlighted the importance of such a supply chain improvement process. One important added-value of the methodology, particularly phase 5, is the touch points with management processes that showed complementarities between business processes modelling and other optimisation techniques (i.e. linear programming, etc.). Administration and Communication are not influenced by the application of the methodology since they do not focus on staff trainings to EA nor communication activities.

6. Conclusion

The investigation on enterprise architecture literature carried out in this study provided a better understanding of enterprise architecture concepts and frameworks. It also summarised the most important progress made in this field during the last thirty years. When exploring existing enterprise architecture frameworks, it was realised that there is not really a focus on supply chain analysis despite its potential advantage for all stakeholders. What we propose here is holistic framework that allows:
• Taking into account environmental trends, which guide enterprise strategy establishment and aligning Information Technology with business strategies. This leads to a much better utilisation of IT.

• Analysing existing enterprise architecture and providing appropriate indicators to reflect current situation and identify the level of SCOR and business capability models integration.

• Developing a reference model based jointly on SCOR and Business Capabilities approach. Such model is very useful when it comes to supply chain analysis and improvement.

• Focusing on supply chain sub-processes and identifying improvement opportunities through process flow modelling.

• Supply chain performance improvement based on SCOR-based analysis and by the use of lean optimisation tools. Therefore, proposed methodology highlights complementarities between SCOR model and lean approach (Kent et al. 2007).

Furthermore, S-BEAM combines a set of tools to bridge the gap between strategic and operational level. In fact, the new reference models provide the link between enterprise strategies and business processes. SCOR-based modelling allows to identify improvement opportunities at a more operational level and finally the deployment of optimisation techniques to complete the improvement process.

Enterprise Architecture development is a long term process that requires investment and involvement of all stakeholders. In our work, we have developed and applied a top-down methodology while focusing on main concepts, methods and tools that impact supply chain configuration and performance. The framework can be improved by establishing other views such as organisations and infrastructures.

Notes

References


