

Case of Enterprise Architecture in Manufacturing Firm

Alicia Valdez, Griselda Cortes, Sergio Castaneda

Research Center
Autonomous University of Coahuila
Coahuila, Mexico
Email: aliciavaldez@uadec.edu.mx,
griselda.cortes@uadec.edu.mx,
sergiocastaneda@uadec.edu.mx

Gerardo Haces, Jose Medina

Research Center
Autonomous University of Tamaulipas
Tamaulipas, Mexico
Email: ghaces@uat.edu.mx, jmedina@uat.edu.mx

Abstract— The small and medium enterprises (SME's) have a low level of survival and are facing serious problems like access to financing, weak management capacity, poor information about market opportunities, limited information about access to innovation and research funds, new technologies and methods of work organization, the integration of its key processes into information and communication technologies (ICT's). The methodology of Enterprise Architecture (EA) can provide a model of integration supported with strategic planning, integrated by partial architectures like business, data, applications and technology. In this study case, we are providing information that was collected from different sources of a medium manufacturing firm to design and implement an EA. As a result we get to the identification of strategic changes supported by the methodology, the assessment of option for change, and a change plan for the adoption of the methodology in their processes; those processes must improve their competitiveness and productivity.

Keywords-Enterprise architecture; Strategic planning; Manufacturing companies.

I. INTRODUCTION

The EA is a methodology which is looking to provide a framework for the companies, for the use of the information in the processes of the business [1]. EA consist of methodological frameworks, architectural frameworks, technologies and standards [2]. The identification of the key processes of the companies in the manufacturing sector located in the areas of marketing, engineering, logistics, productivity and business management, will provide important guidelines for the design of the EA. Studies conducted by researchers in Germany indicate that the administration of the EA is a factor that leads to changes in the companies. They found the impact of 5 dimensions to take advantage of the benefits derived from the EA [3]:

- Quality of the EA
- Quality of the infrastructure of the EA
- Quality of service of EA

- Culture of EA
- Use of the EA

The five dimensions are important to achieve a successful EA, with the realization of benefits measured by the EA Benefit Realization Model (EABRM) [3].

EA is used as a strategic tool and a mechanism to support the alignment between business strategy and ICT's. It also represents a change in the organizational learning, and not just a change of intellectual learning, but learning to cooperate and share information across the entire enterprise [4]. It enables companies to achieve a logical balance between technological efficiency and innovation seeking competitive advantages. Therefore it is necessary to create strategic solutions to enhance the capabilities of enterprises and respond with agility to the challenges, be they business or technology, that today's markets require.

The SME's are major generator of employment in Mexico (7 of 10 jobs are provided by them) [5]. The design and implementation of EA in support of the strategy of SME's in the manufacturing business sector, will increase the competitiveness and productivity of these companies.

The main purpose of this article is designing and implementing an EA for SME's for the manufacturing sector that support the innovation and competitiveness in the national and global market through methodologies, frameworks, technologies, and standards. This research can be replicated in SME's in the manufacturing sector of metalworking.

This paper is structured as follows: In Section II the state of the art is presented. In Section III, partial architectures, business, application, and technology are described. Also, the values of the company for the study are stated. Section IV describes the principal findings of the study application of each partial architecture and their final recommendations. Section V presents conclusion and future work.

II. STATE OF THE ART

Porter defines innovation as the creation of new products, processes, knowledge or services by using existing, or new scientific, or technical knowledge. Furthermore, Porter also mentions that firms are evolving into value chains based on intangible assets, such as knowledge, technology, intellectual property, and others [6].

Afua also defines “innovation as the use of new technological knowledge, market knowledge, and business models that can deliver a new product, or service, or product/service combinations to customers who will purchase at prices that will provide profits” [7].

Consequently, the "Innovation Economy" involves the production and generation of knowledge, and its application in products, processes, and services. Thus, it has become the main asset for developing dynamic competitive advantages [8].

Innovation is the most important topic required for companies to grow successfully. In addition, some factors are changing the environment where the companies are competing. Among these factors include [9]:

- Access to Knowledge: Permit to companies has access to the best ideas, technologies, research resources, and experts at low cost.
- Trade Barriers: Are rapidly being dismantled, thus opening up all markets to global suppliers.
- Access to Capital: The funds may now seek opportunities on a global basis, and companies must compete internationally for capital.
- Technological Obsolescence: Market life cycles are now less than product development cycles. In addition, companies are developing new methods to reduce their product development times.

A study by the Centro de Tecnologia Avanzada A.C. (CIATEQ) developed in 2008, found insufficient capacity of SME’s for the production of knowledge and technology, little demand for them, and the disconnection between demand and possible public offering [10]. The study reflects that SME’s had greater difficulties in order to integrate into the productive chains. In addition, there is a lack of coordination between the system of technological innovation and the technological demand from firms.

In the adoption of new methods for the organization of work and innovation, the EA methodology was placed into consideration. EA is a methodology that aims to provide companies with a framework for the use of the information in business processes in ways that support their business strategy [4], and provides the strategic alignment between the business strategy and the ICT’s.

Some frameworks have been created for providing a guide or method for the establishment of the EA. These are:

- The Zachman Framework.
- The Department of Defense Architecture Framework (DoDAF).
- The Open Group Architecture Framework (TOGAF).

The Zachman Framework [11] was created by John Zachman in the early 60’s at the International Business Machines (IBM) Corporation. Consequently, he developed the framework to define the information systems. This combines rows and columns that represent the perspectives, views, and descriptions types. The perspectives include scope, business model, systems model, technology model, detailed representations, and company’s performance.

The description types are data, function, network, people, time, and motivation. Therefore, Figure 1 shows the Zachman Framework with its elements. Each cell contains a set of elements that represent diagrams or documents on the specific architecture and the level of details. For example, in the column of the functions or processes with line of objectives and scope, the cell has a list of processes which run the business.

Ylimaki and Halttunen say that all the columns and rows are important because they form the abstractions of the company [12]. Thus, each cell must include a primitive graphical model which describes the company from the viewpoint of the perspective that it is analyzing.

The Zachman Framework established the basis for the next generations of frameworks. This includes DoDAF, which later became TOGAF, which is based on the Architectural Development Method (ADM).

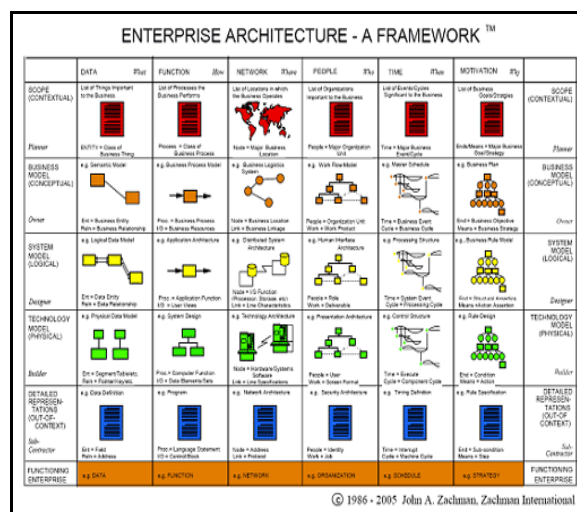


Figure 1. The Zachman Framework Extended [13]

In Figure 2, nine phases were represented. Therefore, these phases are preliminary analysis, architecture vision, business architecture, information systems architectures, technology architecture, opportunities and solutions, migration plan, implementation of governance, and architecture change management. All these components of TOGAF generate deliverables in the form of diagrams, flowcharts, structures, definitions, and other artifacts.

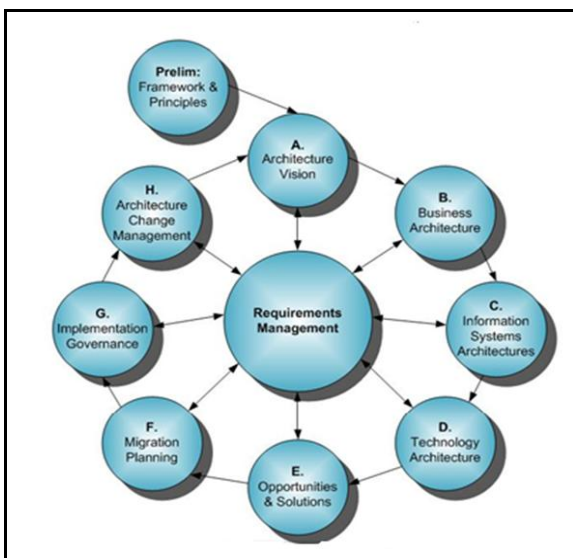


Figure 2. Phases of TOGAF [14]

Every framework has a common factor. They aim to empower the company through the ICT’s search which helps to increase the productivity and the competitiveness of the company.

With the increment of complexity in the companies, the needs of data processing are increasing [13]. In this case, references about TOGAF and Zachman Framework has been taken [11]. This is used to construct the design proposal of the architecture. In addition, software designing tools like Essential Architecture Manager and the editor Protégé Ontology Editor Version 3.4, have been used in the management of the data in the architecture design.

Other researchers have developed advanced applications of EA, as Bernard [15] who has defined EA as a holistic management, planning, and documentation activity, and has introduced the EA Cube Framework and implementation methodology. Where lines of business were defined as five sub-architectures: Strategic initiatives, business services, information flows, systems and applications, and technology infrastructure.

“Newer approaches as business services, exemplifies how EA can link strategy, business, and technology components across the enterprise within a

service bus that encompasses platform independent horizontal and vertical EA components” [15].

Ahlemann, Stettiner, Messerschmidt, and Legner establish that the Enterprise Architecture Management (EAM) is a driver of strategic architecture initiatives as: The implementation of reference models and industry norms, with the goal of adopting best practices, standardization and harmonization, with the goal of reducing the heterogeneity and complexity of business processes, applications, data, infrastructure technology, service oriented and modularization , with the goal of creating reusable services and modules [16].

III. PARTIAL ARCHITECTURES

Research and studies in Europe indicate that the EA is a driver for transformations in companies [3]. Orantes, Gutierrez and Lopez mentioned that companies should be constantly evolving, redefining business processes to achieve business architecture (BA) which is the basis for subsequent architectures [2]. The data flow of the study is shown in Figure 3.

With these premises, partial architectures have been constructed. However, the first is the BA.

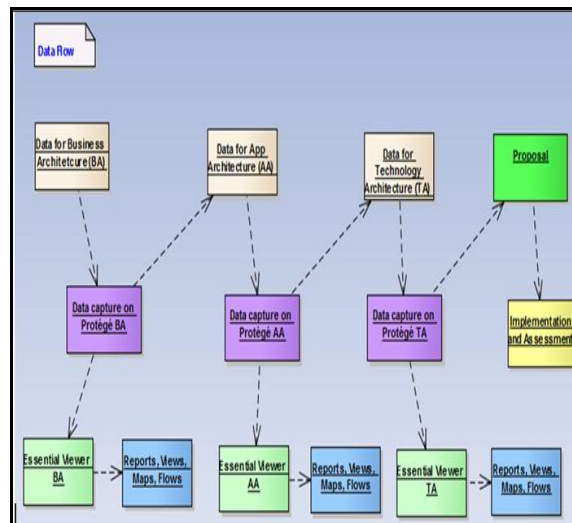


Figure 3. Data flow of the EA

A. Business Architecture

The purpose of the BA is to define the business, document organizational structure, identify and define business functions and processes, relying on strategic planning with their areas of interest [17]. The BA involves some elements of the company like the mission, vision, objectives, goals, values and policies; business processes, procedures and functions, and organizational structure, situational analysis, customers, markets, products, and long, medium, and short strategies.

The company of the study case is a medium enterprise that provides raw material to the large steel companies in northeast of Mexico. This company was established in 1982 to meet the needs of the industry in the manufacture and machining of metal parts. Consequently, the machined parts are made through computerized numerical control machines (CNC). The main products which were manufactured are generally forklift parts, rotating joints, plates thousand holes (clamps, screws, etc.), and various mechanical equipment parts and assembly work. The company has 65 employees. Figure 4 presents some data for the BA.

The structure of the company has 4 levels, corresponding to the CEO and Sales manager at the top position. As follows, these levels include Head of production machining, Head buyer, Head finance, and Human resource manager. Other levels have Supervisors for machining and pailer areas.



Figure 4. Elements of the Business Architecture

The company competes in the regional market of Mexico, and has a local quality certification. Their strategy is to produce high quality metals that the markets are demanding for.

B. Applications Architecture

The Applications Architecture (AA) contains the software products that the company has for the support of the processes. The objectives, principles, and capabilities that govern this architecture are presented in Table I.

The objective of AA is defined as the best kinds of applications to manage data and support business processes with the minimum packaged applications. As a result, the capabilities for the management of the AA are the analysis, design, programming and implementation of information systems, search packaged solutions tailored towards the needs of the SME's, and providing technical support for software and hardware in all the company. Some of the current

applications are presented in Table II. In this case, the applications are related to the processes that supports the firm.

TABLE I. BASIS FOR THE APPLICATIONS ARCHITECTURE

AA	Name	Description
Objective	Define the best kinds of applications to manage data and support business processes.	Define the best applications that support the business processes.
Principle	Customizing minimum packaged applications.	Minimize app package, customization will improve the ability to ensure ongoing maintenance and maximum value obtained from the adoption of a package solution.
Capabilities	Analysis, design, programming and implementation of information systems. Search packaged solutions tailored to the needs of the SME's Provide technical support for software and hardware throughout the company.	Domain in the analysis, design, programming and implementation of information systems. Domain in search packaged solutions tailored to the needs of the SME's Domain to provide technical support for software and hardware.

TABLE II. VALUES FOR INSTANCES OF APPLICATIONS ARCHITECTURE

Name	Description	Domain of App	Performed by business processes
Stock Information System	Management of the inputs and outputs of the company general store.	Update catalog of items, articles inventory processing.	Registry inputs and outputs of goods and raw materials.
Quality	Spreadsheets records quality of finished products.	Data of finished products according to production plan.	Verify the manufacturing process according specifications with production.
Client IS	Manage Client Portfolio.	Update Clients Portfolio, Electronic Billing.	Client Portfolio.
Financial IS	General Financial System.	Update chart of accounts, sub and sub-sub. Update Cost-Centers.policies for debit and credit accounts. Update the information of credit banks.	Accounting Manager.

C. Technology Architecture

The Technology Architecture (TA) represents the computational equipment that supports the applications for the operation of the company. The objectives,

principles, and capabilities of TA are displayed in Table III.

The consolidation of the technology infrastructure is the main objective, with minimum diversity for maintenance purposes. The capabilities are complex because TA manages communications and networks. Also, it provides technical support and various services like platforms integration and monitoring. Thus, Figure 5 presents the equipment.

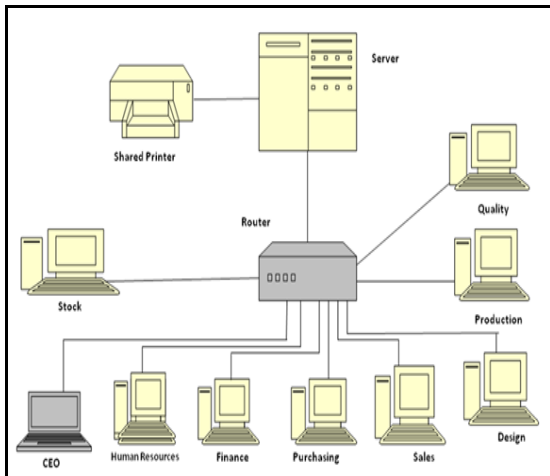


Figure 5. The computational equipment

The company has one server with 9 computers in the local area network. However, one shared printer provides the printing services. Other areas as quality, purchasing, sales, production, design, finances, human resources, and the CEO are supported by the equipment.

TABLE III. BASIS FOR THE TECHNOLOGY ARCHITECTURE

TA	Name	Description
Technology Principle	Minimum diversity of technological products	
Objective	Technology infrastructure consolidation	The technology infrastructure will be consolidated in the company
Principle	Minimum diversity of technology products	Minimum diversity for better maintenance of equipment
Capabilities	Software management services, hardware platform services, security services, technical support, communication and networking services	Ability to acquire, install and configure networking and communication. Ability to detect and correct faults in computer equipment. Ability to manage all software. Ability to manage hardware platforms.

Therefore, one equipment can be used to run various applications.

Table IV summarizes the results of the architectures integration with the processes, applications, and technology that supports the application.

TABLE IV. RESULTS OF THE INTEGRATION

Areas	Process 1	Process 2	Process 3	Process 4	Application	Technology
Quality	Controls of input materials, components and consumables	Verify the production plan meets specifications	Testing and inspection using ultrasonic methods or industrial inspection	Identify causes of non-conformity in items or lots and take corrective action	Spreadsheets	Computer connected to LAN and internet access
Training	Planning and monitoring The Training Business Plan	Detect training needs of business areas, especially productive areas			There is no application for this process	There is no technology for this process
Shipments	Shipment management of finished products				There is no application for this process	There is no technology for this process
Billing	Billing management				Billing information system	Computer connected to LAN and internet access
Production/Machining and Pailer	Program production cycles	Cutting, marking, machining and forming plates and steel profiles	Management of fabrication process	Calibrate equipment periodically	Production information system	Computer connected to LAN and internet access
Sales	Sales management	Detecting customer needs			Clients Information System	Computer connected to LAN and internet access

IV. RESULTS

After the design of the partial architectures in this firm, the results show that two processes are not completely supported by applications and technology. These include Training and Shipment.

E-commerce which could improve the sales volume and increase productivity is highly recommended when rethinking a strategic planning of the company. Therefore, quality and production processes are supported by spreadsheets.

The Microsip Manufacturing System [18] is a solution designed for SME's that do not have applications in the production areas. Also, the study of EA confirms the need that had already been detected to automate production processes. Thus, the advantages of the software are:

- Planning and control of production.
- Calculation of production.
- Prioritize work orders.
- Monitoring of workers.
- Monitoring of machines.
- Simulation of production orders.
- Production reports.

- Tracking production.
- Dynamic queries with access to all production data.
- Control of shipments.
- Conversion to graphics.
- Integration with other installed modules of Microsip brand.

With this special solution, SME's control of the shipments of finished products will be achieved.

Information systems are used in training areas in order to manage the main elements, such as courses, facilitators, identifying the needs of the plant for training, and the proposed dates.

The activities of internal or external training generate a dynamic company that leads to improved productivity and competitiveness.

Regarding the proposal to integrate e-commerce firm on a long term, the following activities were proposed:

- Development of a dynamic website to promote the manufactured products.
- Investment in ICT's could increase competitiveness and growth into new domestic and international markets.
- Establish a definition of roles, functions, and policies for recategorizing.
- Get an open line of credit to finance the expansion plan and the purchase of equipment and machinery.
- Competition is intense in the sector of this industry. Thus, achieving a better position in the market is necessary to identify and select new potential customers, increase advertising in all media, expand their sales channels, and follow up through customer service.
- Fostering a culture of total quality in the whole company.
- The change plan is long term, and it includes management activities to close gaps encountered and the acquisition and implementation of information systems and technology.

In addition, this project helps in meeting the needs of SME's companies to propose affordable solutions that use business management resources and technology, to solve problems. This study is limited to manufacturing SME's.

Other findings in terms of improvement show that SME's have demonstrated alignment with business strategy to drive a strong organizational culture and technological infrastructure.

V. CONCLUSION AND FUTURE WORK

In this paper, the EA methodology was designed and applied in a medium manufacturing company with information provided from different sources of the firm, where the applications and technology that support their business processes were analyzed, linking them through tables and charts. As a result we found that the company requires an ICT's investment in production and quality processes, which would integrate the information that is obtained in real time and would expedite the processes of decision-making, as well as the integration of e-commerce to the sales strategy. This can help increase the productivity of the company.

The advantage of this approach lies in that the company is analyzed holistically, especially in its core processes.

Given the importance for EA, organizations will increasingly support their EA efforts as a virtual reporting structure with collaboration of all people to deliver substantial business value.

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