Leveraging the Zachman Framework Implementation
Using Action-Research Methodology – A Case Study:
Aligning the Enterprise Architecture and the Business Goals

Juan Manuel Nogueira, David Romero*, Javier Espadas, Arturo Molina

Tecnológico de Monterrey, Mexico

Abstract. With the emergence of new enterprise models, such as technology-based enterprises, and the large quantity of information generated through technological advances, the Zachman framework continues to represent a modelling tool of great utility and value to construct an enterprise architecture that can integrate and align the IT infrastructure and business goals. Nevertheless, implementing an enterprise architecture requires an important effort within an enterprise. Small technology-based enterprises and start-ups can take advantage of enterprise architectures and frameworks but, because these enterprises have limited resources to allocate for this task, an enterprise framework implementation is not feasible in most cases. This paper proposes a new methodology based on action-research for the implementation of the business, system and technology models of the Zachman framework to assist and facilitate its implementation. Following the explanation of cycles of the proposed methodology, a case study is presented to illustrate the results of implementing the Zachman framework in a technology-based enterprise: PyME CREATIVA, using action-research approach.

Keywords: Action-Research, Enterprise Architecture, Technology-Based Enterprise, Zachman Framework

1. Introduction

New technology-based enterprises¹ rely on developing their technologies to compete within defined markets. These new technology-based enterprises, in many cases, are spin-offs from important research and academic projects that respond to an opportunity identified in the market and they confront a wide range of problems related to technology and knowledge management (Bernus et al, 1996). These technology and knowledge issues arise from the quantity of information generated within research projects and from addressing this information to create business value for the enterprise. To structure, organize, access and capitalize on this information is vital for start-ups. As an enterprise grows and becomes more complex, management makes greater demands for information for decision-making (Xu and Xu, 2011). It requires timely access to information and useful, accurate and consistent information that can be easily interpreted throughout every business unit in response to rapidly changing business conditions (Li and Warfield, 2011). To achieve this accurate organisational information flow, an Enterprise Architecture (EA) is widely-used to document, develop and establish the organisational data for the entire enterprise (Erol et al, 2010; Engelsman et al, 2011; Narman et al, 2011; Van Sinderen and Almeida, 2011). Unfortunately, most of the existing EA frameworks are focused on medium and large enterprises, and their implementation requires a significant effort within an enterprise (Jacobs et al, 2011). As our case study is focused on a start-up enterprise that spun off from an academic research project, this work proposes the use of an adapted action-research methodology to assist and facilitate the implementation of an EA framework: the Zachman framework, for small scale enterprises. By implementing the Zachman framework with the action-research methodology proposed, this paper aims to:

- Create an easy-to-use methodology for developing an enterprise architecture in a technology-based enterprise and/or start-up (small scale enterprise) based on the Zachman framework.
- Drive the research’s results within a (small) enterprise to real business value products, through an action-oriented process.
- Define models for business, system and technology implementations to help in the alignment of the activities that an enterprise carries out to achieve cohesive goals across its IT and the other business units (Luftman, 2003).

¹Corresponding author: Tecnológico de Monterrey, Campus Mexico City, Del Puente 222, Col. Ejidos de Huipulco, Tlalpan, 14380, México, D.F. E-mail: david.romero.diaz@gmail.com Phone +52 55-54831605 Fax +52 55-54831606
- Support decision-making in all business units that will be based on more accurate and timely information by integrating the enterprise entities (processes, information and resources) needed to facilitate the information sharing (Vallejo et al, 2011).

This research work is organised as follows: the initial sections describe the main concepts involved and establish the theoretical foundations of this research; the fifth section presents a methodology based on action-research to support the implementation of an EA framework: the Zachman framework. The final section describes a case study where the proposed methodology was applied within a technology-based start-up enterprise named: PyME CREATIVA. When the implementation of an EA framework is achieved, standards models (business, system and technology) are integrated across the organisation and its enterprise architecture achieves a certain IT maturity level which drives business processes and strategies as a true standard model (Luftman, 2003).

2. Enterprise Architecture in SMEs

From an economic perspective, most countries are primarily based on Small and Medium Enterprises (SMEs) without extensive ICT infrastructure and experience (Knoll et al, 2007). Supporting their position and helping them to integrate into existing ICT infrastructure would have a considerable beneficial impact on both the local and even the world economy (Knoll et al, 2007). Since SMEs have less financial capital to invest in technological capabilities, human resource and management levels, they experience enormous pressures to reduce their operating costs and to close the gap between the SMEs and the large-size enterprises in performance indices such as the rate of return on total assets and the rate of return on net sales (Wang et al, 2008). Nevertheless, little progress has been made in integrating business processes across the SME’s supply chain and utilizing the benefits of e-technology based information networks among its partners. Consequently there is an excellent opportunity for SMEs to tap into the lack of exploitation of IT to improve their performance (Kim et al, 2008). It is import to mention that SMEs need to implement a business process based approach to leverage this opportunity and increase their competitiveness.

To enable a SME to use a business process-based approach, the enterprise needs a means of conceptualizing itself in terms of its processes. Ideally, this approach can be as simple as using traditional organisation charts that show business units and reporting relationships. There are other common approaches of representing the high-level processes that comprise the organisation. Some models depict within an organisational box, the processes that link suppliers and customers, some stress product lines, while others rely on an analysis of value chains. Still others focus on abstract business process like: new product development, supply chain management, sales and marketing, and/or other enabling processes. However, processes need to be modelled and they must be managed and measured. Many enterprises have come within reach of a kind of business process modelling approach by using the Balanced Scorecard. Nowadays, most enterprises have focused on creating an Enterprise Architecture that pictures an organisation by means of an Enterprise Architecture (EA) model.

An EA approach helps SMEs to align business and ICT resources and relate them to the fundamental principles and common methodologies governing the entire enterprise information. Architectural frameworks are a convenient way to support such methodologies and separate roles that facilitate and implement these methodologies as needed (Shah et al, 2007). Kim et al (2008) conclude that SMEs need to develop a sound business rationale by aligning strategic business needs and technological assets. This requires analysing key strategic, operational, technological and organisational issues along with financial investment justification by considering all the available options of building, buying and renting the systems. Finally, it is crucial for SMEs to embrace their supply chain management but to start small in execution from an orchestrated business process perspective by aligning strategies to their environment and by linking strategies to actionable, controllable and measurable key process indicators (Kim et al, 2008).

Table 1. Benefits of an EA in SMEs (Adapted from Shah et al, 2007)

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business-Related</td>
<td></td>
</tr>
<tr>
<td>Human Resources</td>
<td>Acquire and preserve knowledge from employees and consultants.</td>
</tr>
<tr>
<td>Adaptability</td>
<td>Facilitate knowledge acquisition necessary for changing systems and adopting new components.</td>
</tr>
<tr>
<td>Operational improvement</td>
<td>Design and model business processes. Analyse and reengineer processes.</td>
</tr>
<tr>
<td>Decision-making</td>
<td>Represent an enterprise’s layers and components modularly to let the organisation make business decisions in the context of a whole instead of a stand-alone part.</td>
</tr>
<tr>
<td>IT-Related</td>
<td></td>
</tr>
<tr>
<td>Complexity management</td>
<td>Manage the complexity of information that has to be handled for a few people.</td>
</tr>
<tr>
<td>Technical resource improvement</td>
<td>Identify opportunities for a better technical and infrastructure implementation.</td>
</tr>
<tr>
<td>Knowledge management</td>
<td>Manage and share knowledge modularly so it can be visualized across different levels.</td>
</tr>
<tr>
<td>IT Visibility</td>
<td>Small IT resources and local systems are more aligned to business strategies and are better placed for responsiveness.</td>
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</table>
The strategies presented by Kim et al (2008) can be achieved with the assistance of an Enterprise Architecture implementation. As Table 1 describes, the benefits of an EA have a critical impact on SME competitiveness, from a business as well as an IT perspective. It is this impact that drives this work, in the sense that implementing an EA framework is not a trivial task. According to Luftman (2003), IT alignment evolves into a relationship where the function of EA adapts IT and business-related strategies together. As such, business and IT alignment refers to IT in an appropriate and timely manner, in accordance with strategies like the ones presented in Table 1. This research work proposes the use of an adapted action-research methodology to facilitate the implementation of an EA framework to achieve the implementation of such strategies.

3. Enterprise Architectures

Commonly, a framework has two definitions in relation to an enterprise, the first definition defines a framework as a primitive structure; this is the beginning of the enterprise construction. The second definition indicates that a framework functions as a reference or system model to describe a whole architecture. The primary objective of any framework is to define the relevant requirements of a business that are applied to the evolution of its architecture. A framework applied to an enterprise is a simple logical structure to classify and organise a descriptive representation of the enterprise that is significant for the manager(s) as well as for the development of the enterprise systems (Whitman et al, 2001).

Moreover, enterprise architectures are models that define in detail a series of technological and business components of an enterprise (Bolles, 2004). The term enterprise architecture can be defined as a structural set of models that represents invariant blocks of construction of the whole enterprise. An enterprise architecture could be also considered as the base for the design and implementation of all enterprise systems, in this way, the enterprise architecture is a “framework” that shows the interrelations of a great number of different and separate models which describe parts of the whole system and its functions (Bernus et al, 1996). Enterprise architectures are helpful to define a consistent language to describe a business, its information and its technology which is used to create, manage and distribute such information and, in addition to provide a discipline to providing a discipline to control IT costs, to support decision-making processes and to consolidate IT resources, making possible a better scalability of the IT infrastructure according to the business demands (Bolles, 2004; Vallejo et al, 2011).

Furthermore, enterprise architectures are reference models of how an organisation could reach its actual and future objectives by studying the key strategies of the business, relating to information and technology and their impact on the functionality of the business. Each of these strategies is a separate discipline and the enterprise architecture is the bridge that integrates each of the disciplines in a cohesive framework as shown in Figure 1 (Pereira & Sousa, 2004).

![Figure 1. Relations between Architectures (Pereira & Sousa, 2004)](image)

The business architecture reflects the definition of the business strategies, processes and functional requirements of an enterprise. It is the base for identifying the information systems requirements, over which the business activities will be supported. The application architecture provides a focus model for the development and/or implementation of applications that guarantee the business requirements and assure the required quality to cover the business necessities. The information architecture describes the physical data and logical aspects; this architecture is the result of modelling the information requirements necessary to support the process and functions of the business. The technical architecture provides the base to support the applications, data and business processes identified in the previous levels. In this architecture the computing services are identified and planned to form the enterprise technological infrastructure. Finally, the product architecture is a subset of the technical architecture that identifies standards and configurations for the integration or adoption of technologies and products inside the technical architecture (Pereira & Sousa, 2004).
Enterprise architectures should be evaluated from the highest level, where the changes are performed to adjust the enterprise resources. Essential issues should be considered in each selection of an enterprise framework, such as organisation domain and stakeholders’ scopes. Since there are different frameworks that share similar goals and characteristics, it is important to understand the similarities and differences of each one to find a framework that fits with the required solution. The purpose of conducting an analysis of EA frameworks is to facilitate rational decision-making about the most suitable framework to create the enterprise architecture in a particular enterprise (Johnson et al., 2007) (Vallejo et al., 2011). Table 2 shows a comparison of different EA frameworks:

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Structure</th>
<th>Top-Down</th>
<th>Abstraction</th>
<th>Artefact</th>
<th>Adoption</th>
<th>Research Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERA</td>
<td>M</td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>CIMOSA</td>
<td>H</td>
<td>M</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>Zachman</td>
<td>H</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>GERAM</td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>FEAF</td>
<td>M</td>
<td>M</td>
<td>L</td>
<td>M</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>TOGAF</td>
<td>H</td>
<td>M</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>M</td>
</tr>
</tbody>
</table>

As summarized in Table 2, requirements are evaluated against different frameworks (Lapkin, 2004). These requirements are taken from technology-based needs and they represent the common high-level attributes that an EA framework should have. A framework must provide structure, a normalized schema of information classification. Moreover, a framework should be able to decompose (top-down approach) the entire enterprise from its highest level. It should be possible to abstract every enterprise business entity and provide artefacts to document them. Also, the adoption of every framework was evaluated and finally the research focus is important in this implementation. Overall, the Zachman framework is the most suitable for implementation in technology-based enterprises and it is truly the most well-known model in the context of enterprise architectures. The reason is that it uses a very extensive and flexible frame, and it does not have any imposition and/or restriction over any user of a predefined artefact system (Pereira & Sousa, 2004).

In summary, an enterprise architecture is a tool for the development of standard methods to analyse the information systems over which an enterprise operates (Whitman et al., 2001) and according to Anaya & Ortiz (2005) an enterprise architecture has two principal uses: (1) As an engineering tool to define an information guide that is required and complements the methodologies used by the enterprise, which define the steps to be followed by different actors to generate those knowledge pieces to complement the enterprise architecture, and (2) As a management tool, after the engineering phase, providing the managers with a view of the relations between the artefacts that are found in each architecture level.

4. Zachman Framework

Nowadays, the enterprise information systems are managed by the business strategies of the top level of an enterprise, in spite of the small scale of the functional processes that these information systems carry out. Zachman (2003) has proposed a framework for IT architectures, in which all the aspects of an information system architecture are depicted, from the high level business strategies to the information systems coding (Schoch & Laplante, 1995).

The Zachman framework stands out as an architecture that represents the artefacts of information systems, providing assurance of standards to create properly integrated information environments. The framework describes the architecture through two independent aspects in a matrix, the rows represent the different perspectives that can be used to see the business, a situation, an opportunity or a system and the columns, that represent the different dimensions in which each one of the business, situation, opportunity or system perspectives can be applied (Pereira & Sousa, 2004).

Furthermore, the Zachman framework is composed of five roles or perspectives, represented in the rows of the framework, which are similar to the roles of an architectonic design (Steinle & Nicklotte, 2003; Hay, 1997):

- **Planner (focused on the scope).** This is a contextual perspective where the direction of the enterprise and the purpose of the business are defined. It is also a view of the industry, concerned with the definition of the nature and purpose of the business, which are necessary to establish the context of any system development.

- **Owner (focused on the deliverables).** This is a conceptual perspective of the business, represented by the business model where the nature, structure, function and organisation of the business are defined.
- **Designer (focused on the specifications and expectations of the owner).** This is a logical perspective of the business, represented by the system model, where the business model is described in terms of information architecture concepts.

- **Builder (focused to the production and the assembly of the product).** This is a physical perspective of the business, represented by a technological model, where the technology used to deal with the necessities of information processing is defined. In this perspective, relational databases are selected for the networks (or vice versa), some programming languages and structures are defined and selected, and some user interfaces are described.

- **Subcontractor (focused on the creation of reutilized components according to the specifications of the constructor).** This is a detailed representation or perspective of the list of programs, databases and network specifications required to construct a particular system. This information should be represented in a particular programming language.

The Zachman framework tries to resolve six basic questions that progress towards specific dimensions or abstractions. It correlates six questions and they are represented in the columns of the matrix (Steinle & Nickolotte, 2003; Hay, 1997):

- **Data (What).** Each row of this column is oriented to the understanding and management of any type of data. It begins with the most important things for the enterprise and as it advances in the rows, the description of the data becomes more detailed.

- **Function (How).** This dimension describes the translation process of the enterprise’s mission into a more detailed definition of its operations, starting from a list of the activity types that conduct the enterprise to the source-codes of its systems.

- **Network (where).** This column is related with the geographical distribution of the enterprise’s activities, starting from a simple list of places where the enterprise will do business detailing the information of these places as rows advance to the description of the communication nodes implemented.

- **People (who).** This dimension describes all the people involved in the business and the introduction of new technologies, starting from a list of those who integrate the enterprise and their activities – detailing the representation of each one as rows advance – and finally describing how they interact with the systems to the person trained to make use of the new systems.

- **Time (when).** This dimension describes the effects of time over the enterprise. This column initiates at a basic level, where business cycles are described in relation with their events, increasing the level of detail related to their functions with each cycle, describing the transformation causes of the entity states and so on until the business events respond correctly according the systems.

- **Motivation (why).** This dimension describes the translation of goals and business strategies for specific purposes, including the expansion of the enterprise’s limitations. These goals are translated and/or transformed in terms of the rows, reflecting the rules implemented in specific programs.

Table 3 presents a simplification of the Zachman framework by Steinkey & Nickolette (2003) indicating the information required in each one of the cells or cabins of the matrix. By using a simplified version of the Zachman framework, enterprises can improve their IT and business alignment, because they are using a structuring framework to define relationships (rows of Table 3) where the function of IT and other business functions (columns of Table 3) adapt their strategies together. According to Luftman (2003) reaching IT-business alignment is an evolutionary and dynamic process, and these process attributes are achieved in this paper by using the action-research approach for carrying out the Zachman framework implementation.
5. Action-Research

As mentioned before, EA frameworks are focused on large and medium enterprises, with complex organisational structures and a significant number of resources to be allocated. For small and start-up enterprises it is very difficult to implement these frameworks, because of the amount of effort (e.g. resources, documentation) involved. When enterprises define organisational structures through EA frameworks, they need to detail infrastructure and processes in order to achieve and sustain alignment demands; this detail focuses on maximizing the enablers and minimizing the inhibitors that cultivate the integration of IT and business (Luftman, 2003). This theoretical-practical work proposes the use of an adapted action-research methodology in order to assist and facilitate the implementation of the Zachman framework in a technology-based start-up enterprise. Also, the research nature of technology-based enterprises requires an action-oriented methodology for architecting their organisation and converting this research into real-business value products.

Action-research can be described as a family of research methodologies that pursues an action or change and a research or understanding at the same time. In the majority of action-research forms, the use of cycles or spiral processes alternating between the action and the critical reflection in the same cycle provides a constant refinement of methods, data and interpretations in favour of the developed understanding of the first cycle (Devlin et al, 1988). Moreover, action-research is a form of internal research that is carried out collectively by a group of participants, whose objectives are to make improvements to its practices and the comprehension of them, making clear that the action-research is carried out across the critical actions of each individual (Kemmis et al, 1988). Furthermore, action-research is more than just problem resolution, since it implies problem planning, seeks to achieve improvements across the learning from the changes that are obtained as result, and is based on a process of critical intelligence to give form to the action and develop the capacities of reflection to restructure the action plans and realize adjustments if being necessary (Altrichter et al, 2002).

In action-research, the researcher wants to test a theory with practitioners in real situations, gain feedback from this experience, modify the theory as a result of this feedback and test it again (Avison, 1999). An experimental research has a series of principles to guide its execution, which may be appropriate for some types of research, but these can inhibit effective changes in some cases. Action-research was developed under dissimilar principles, considering the different characteristics of the majority of qualitative methods, for what this one tends to be (Dick, 2000): cyclical, participative, qualitative and contemplative (reflective). Action-research is an extensive methodology made to illustrate scientific research methods, ideal for its use in the study of technology in the human context. The discipline of information systems seems to be more appropriate to the field of use of action-research (Baskerville & Wood-Harper, 1996). By emphasizing collaboration between researchers and practitioners, action-research would seem to represent an ideal research method for information systems. Such systems represent an applied discipline, and the related research is often justified in terms of its implications for practice, that is why information systems are a good example to demonstrate the benefits of action-research across the software engineering and the systems science, and this is possible because its controls in applications including the real enterprises. Action-research has made some contributions like the contingent multiple-views of the frameworks of systems development (Avison et al, 1999).
Action-research was developed by the Research Center of Group Dynamics (at University of Michigan) to study social psychology inside the model of the theoretical field. In 1951, Kurt Lewin created the action-research model, including the interaction of six phases or states (Baskerville & Wood-Harper, 1996): (1) analysis, (2) diagnosis (fact-finding), (3) conceptualization, (4) action-planning, (5) action-taking, and (6) evaluation.

By 1988, Kemmis et al described action-research as a process of spiral steps that constituted the planning, action and evaluation of the results of the actions taken, generally this process usually begins with a general idea, which must be analysed to focus on the main problem and establish the facts. After a preliminary exploration it will be possible to determine the general action plan. Once this has been done, the action should start implying a strategic change, not just of improvements but also to facilitate the comprehension of the scope of the future. Once this step is done, new data will emerge that can be evaluated for a new planning so that it can be possible to control and evaluate it again, and redefine it if necessary.

Figure 2. Action-Research Model (Kemmis et al, 1988)

As presented in Figure 2, Kemmis et al (1988) explained that in action-research, researchers must follow a set of cycles that consist in:

- **Plan.** The planning phase must originate from a future point of view, recognizing the actions that could be unpredictable or risky, using planning tools to be as flexible as possible and to adapt to any situation not foreseen previously; so it is convenient to consider the risks that could be presented such as real limitations, materials, policies and organisational changes to debate. With this, it can be possible to provide a better training to act adequately before the critical situation and to be able to continue with the implementation of the action.

- **Act.** The action phase recognizes a set of ideas in action, and this will be the platform for new developments in later actions. The action is taken based on the previously established action plan, and admits that in some way it has links with previous practices.

- **Observe.** In this phase it is indispensable to pay attention to all the events that are occurring, to document them and to project a future with this information to then create the base of reflection. The observation must be carried out very carefully and must always be documented, likewise, it has to be planned to integrate the basis for new reflections in the future, allowing the researcher to expand the vision of new points of view and make way for new reflections. Similar to the action plan, the observation must be sufficiently flexible to be able to detect unexpected events, for which, the people dedicated to action-research must carry out a registration of the observations additional to the planned or the expected results; they must be careful with the observation of actions and their effects, as well as the circumstances in which they happened, by not losing the view of the limitations that could change the actions.

- **Reflect.** The reflection phase is the result of the observations; reflection is an active element whose purpose is to make sense of the processes, problems and other unexpected situations in the application of the action with all the strategies. A reflection will be more enriched with the participation of the actors involved, since it helps to construct a base for the review of a new plan considering the different points of view required to examine the results in detail. The most valuable element of the reflection is that it permits the researchers to support their experiences, because they can judge if the results are the expected ones and then continue. So, the results can indicate the limitations of the action, and in the most relevant way, what things are possible now for the redefinition of the future action plan.
After the reflection phase, one must be able to re-formulate the steps for planning while at the same time it will be possible to better understand the process for making strategic changes that lead to valuable improvements, by being more systematic and more rigorous than in common habits of daily life; involving other people in some stages who can contribute with solutions or information to the action-research. These four phases must not be viewed statically, but as spaces of the spiral of the action-research that integrates a result which will reflect the submission of the planned actions put in practice, observed and reflected offering a value-added result (Kemmis et al, 1988).

In summary, action-research must include the diagnosis of the problem, its analysis and a strategic plan; in which the action plan refers to the implementation of the strategic plan; and then continues with the observation that includes an evaluation of the actions taken based on the methods and the techniques used; in this case the reflection (learning) means to think about the results of the evaluation and about the process instead of the action-research, which will allow the identification of a new problem or problems and therefore a new cycle of planning or diagnosis, action, observation or evaluation and reflection or learning (Swann, 2001).


According to the literature review, action-research methodology results in a sustainable methodology for its adaptation of the implementation of the Zachman framework, since “action” and “research” work together to help to reduce the time required for the framework’s implementation. Adapting the action-research model proposed by Susman (1983), the following action-research model (see Figure 3) is proposed for carrying out the implementation of the business, system and technological models of Zachman’s framework in a technology-based enterprise.

![Figure 3. Action-Research Methodology proposed for the Zachman Framework Implementation (Adapted from Susman (1983) model)](image)

Susman’s action-research model (1983) was selected and adapted because of its diagnostic phase that will help to better understand the enterprise context where the Zachman framework will be implemented to build the enterprise architecture, starting with an action-planning phase in the first cycle (business model) towards the second (system model) and third (technology model) cycles of the methodology proposed.

As presented in Figure 3, the action-research methodology proposed is composed of three cycles corresponding to the business, system and technological rows of the Zachman framework, and in each phase of the cycles, it can be observed as an internal cycle of those activities that should be carried out respecting the action-research phases.
The action-research model proposed (see Figure 3) adapts the nature of the action-research methodology by modifying the spiral order of the improvement cycle according to the proposed methodology, which can be made upon the finishing of a cycle or going back from the current cycle to the previous cycle to make the pertinent improvements. The improvements can be made or the cycle can be executed a number of times until the expected results are obtained. The jump will only be possible to the immediate previous cycle, since this is one of the rules that Zachman (2003) indicates for implementing the framework.

In the following paragraphs, the action-research methodology proposed for the implementation of the Zachman framework in a technology-based enterprise will be described.

**Cycle 1 – Business Model.** It consists of five phases to implement the *business model perspective* of the Zachman framework. This perspective provides a conceptual representation of the enterprise business model, which constitutes the business design. It depicts the business units, the business processes and their interactions to achieve the enterprise mission (see Figure 3):

1. **Diagnosis.** In this phase we will be able to obtain a diagnosis of the actual situation or state of the enterprise, which requires an extensive research on the enterprise documentation, if it is available, as well as to know its history, objectives and to meet the main actors that will carry out the framework implementation activities and process, as well as the actors that have decision-making power or are involved in the enterprise’s performance (e.g. executives, project managers, specialists, etc.). This phase is carried out with the objective of making a complete recognition of the exiting situation of the enterprise as the starting point to continue with the action-planning and action-tacking phases. This phase also serves to verify the initial ideas about possible issues during the framework implementation (Kemmis et al, 1988). As part of the diagnostic phase, Zachman framework literature should be reviewed to comprehend the objectives that will be presented and that will make the understanding of the information in each of the *cells* of the framework easier. With this quick literature review it will also be possible to know the scope of each *cell* and the limitations of the information that will be contained in each *cell*. Making a short description of the enterprise, indicating its mission, vision, main activities working-team, etc., will provide a starting point and the possibility for future comparisons in the proposed action-research methodology. With the information mentioned in this first phase, most of the *scope (contextual)* row of the Zachman framework can be filled out.

2. **Action-Planning.** This phase includes three activities:

   2.1 *Stakeholders’ analysis.* In this activity, the positive or negative contributions of all actors involved in a project will be identified and studied. This activity will help evaluate the project environment, comprehend its characteristics, interrelations, and interfaces between two or more defenders or opponents of the project’s strategic planning. A stakeholder’s analysis should include: (a) a list of all actors involved, (b) an evaluation of the importance of each actor involved for the success of the project and (c) a strategy for the interventions, also known as responsibility assignment matrix (Manktelow, 2006).

   2.2 *Future work presentation.* In this activity a presentation of all actors involved in the project should be developed, explaining: (a) what is the Zachman framework? (b) why implement it? (c) what are its benefits? (d) definition of the terms to be used, (e) definition of the architect, (f) presentation of the framework, (g) presentation of the construction process, (h) presentation of the rules to construct the framework, (i) definition of the objectives and scope of the project, and (j) implications and commitments of the working group.

   2.3 *Information collecting tool analysis.* In this activity, questionnaires are the best tools to collect all the information required to better understand each one of the *cells* of the *business model perspective*. Other information compilation tools that could be used are surveys, interviews, meetings, debates, etc. Furthermore, this activity helps to clarify the enterprise’s objectives for establishing a common target towards where all efforts should be directed (*context questionnaire*) and to make clear who are the owners of each business process and their information requirements (*business questionnaire*).

   - **Context (Scope) Questionnaire:**
     - What (Data). List of things that are important for the enterprise.
     - How (Function). List of business processes of the enterprise.
     - Where (Network). List of locations in which the enterprise operates.
     - Who (People). List of the important organisations for the enterprise.
- When (Time). List those meaningful milestones for the enterprise.
- Why (Motivation). List all the goals/strategies of the enterprise.

- **Business Model Questionnaire:**
  - What (Data). Define and describe the essential types of information required for the enterprise operation.
  - How (Function). Identify and describe the fundamental management activities and also supporting activities of the enterprise. Represent them as inputs and outputs of each business process.
  - Where (Network). Specify and describe the availability of the enterprise facilities and their interconnections.
  - Who (People). Identify and define the roles of the individuals participating in the enterprise.
  - When (Time). Determine the order and synchronization for the processes of the services offered by the enterprise, thinking in terms of a master schedule.
  - Why (Motivation). Define the metrics and objectives of the enterprise, using the definition of the business plan as reference.

3. **Action-Taking.** This phase includes five activities:

3.1 **Team meeting.** It is convenient to carry out a meeting to explain the business model row of the Zachman framework to the stakeholder’s team.

3.2 **Questionnaire application.** According to the responsibility assignment matrix, the business model questionnaire should be applied.

3.3 **Results analysis.** The information obtained from the questionnaire applied to the stakeholders involved in filling out the business model row should be compared with the information obtained from the enterprise documentation (scope model row) to make conclusions between both models and unify the collected information.

3.4 **Fill out business model row.** Once the information of the questionnaires and the enterprise documentation has been unified, the next step is to fill out the corresponding cells of the business model row with the proper information. Most common modelling tools for the information representation.documentation of the business model row are presented in Table 4.

<table>
<thead>
<tr>
<th>Modelling Tools</th>
<th>DATA What</th>
<th>FUNCTION How</th>
<th>NETWORK Where</th>
<th>PEOPLE Who</th>
<th>TIME When</th>
<th>MOTIVATION Why</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entity-Relation Diagrams in Business Level</td>
<td>Workflow Diagrams</td>
<td>Logical Network Diagrams</td>
<td>Organisational Charts</td>
<td>Master Schedule</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

3.5 **Presentation of results.** After filling out the business model row, it is convenient to make a presentation to all the stakeholders involved in this phase, with the objective of showing the results obtained that are already projected in the framework.

4. **Evaluation/Observation.** The results presentation activity in the action-taking phase will represent the evaluation/observation phase, in which stakeholders’ comments will be listened to, and will give feedback to the results obtained in the business model row.

5. **Learning/Reflection.** This last phase corresponds to a comparison between the unified information used to fill out the business model row, and the recommendations made in the evaluation/observation phase to improve the business model row information. In other words, the stakeholders should carry out a comparative analysis to project the actual situation (AS-IS) of the business model information versus the recommended situation (TO-BE) for successful business performance (see Table 5).

<table>
<thead>
<tr>
<th>BUSINESS MODEL (CONCEPTUAL)</th>
<th>DATA What</th>
<th>FUNCTION How</th>
<th>NETWORK Where</th>
<th>PEOPLE Who</th>
<th>TIME When</th>
<th>MOTIVATION Why</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entity-Relation Diagram (Business Level)</td>
<td>Business Processes Modelling</td>
<td>Networks Location (Maps)</td>
<td>Organisational Charts (Business Units)</td>
<td>Gantt Graphics</td>
<td>Business Objectives Statements</td>
<td></td>
</tr>
</tbody>
</table>
Cycle 2 – System Model. It consists in four phases to implement the system model perspective of the Zachman framework. This perspective provides a logical representation of the information flows that support the enterprise business processes and are managed by the enterprise information systems (see Figure 3):

1. Action-Planning. This phase includes two activities:
   1.1 Future work presentation. It is convenient to carry out a meeting to explain the system model row of the Zachman framework with the stakeholders. This meeting will help to clarify the kind of information that will be required to fill in this row. In this meeting, only the stakeholders that were selected according to the responsibility assignment matrix should participate by providing the information required to fill in the system model row.
   1.2 Information collecting tool analysis. In this activity, questionnaires are still the best tool to collect all the information required to better understand each one of the cells of the system model perspective. Furthermore, this activity helps the computer systems analysts and other stakeholders to guarantee that the enterprise information systems are satisfying the enterprise information requirements.
   - System Model Questionnaire:
     - What (Data). What information it is important for the enterprise and should be stored to support the business operation?
     - How (Function). Which information systems support the enterprise business processes? What mechanisms and controls are already implemented? What are the inputs and outputs of these systems?
     - Where (Network). What distribution systems architecture is used? How is the connectivity between the information systems and the hardware infrastructure for the remote functioning and/or information transfer?
     - Who (People). According to the organisational chart, what are the roles and responsibilities of each worker? What activities are the most important according to their roles? What tools (hardware or software) are used for guaranteeing the good performance of the work flow activities (business processes)?
     - When (Time). What are the business processes cycles performed in the enterprise? How is the timing estimation of the activities performed? In general, how is the time control performed between phases or activities cycles in the enterprise?
     - Why (Motivation). What are the business process rules and how they are documented?

2. Action-Taking. This phase includes four activities:
   2.1 Questionnaire application. According to the responsibility assignment matrix, the questionnaires should be applied to the corresponding stakeholders.
   2.2 Results analysis. The information obtained from questionnaires applied to the stakeholders involved in filling out the system model row should be compared with the information obtained from the enterprise documentation (scope model row) to make conclusions between both models and unify the information recollected.
   2.3 Fill out system model row. Once the information of the questionnaires and the enterprise documentation has been unified, the next step is to fill out the corresponding cells of the system model row with the proper information. The most common modelling tools for the information representation/documentation of the system model row are presented in Table 6.

<table>
<thead>
<tr>
<th>SYSTEM MODEL (LOGICAL)</th>
<th>DATA</th>
<th>FUNCTION</th>
<th>NETWORK</th>
<th>PEOPLE</th>
<th>TIME</th>
<th>MOTIVATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modelling Tools</td>
<td>What</td>
<td>How</td>
<td>Where</td>
<td>Who</td>
<td>When</td>
<td>Why</td>
</tr>
<tr>
<td>Standard Entity-Relation Model with Data Entities and Relations</td>
<td>Workflow Diagrams</td>
<td>Network Topologies and Connectivity Diagrams</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

2.4 Presentation of results. After filling out the system model row, it is convenient to make a presentation to all the stakeholders involved in this phase in order to present the results obtained in the framework.
3. **Observation.** The results presentation activity in the action-taking phase will represent the evaluation/observation phase, in which stakeholders’ comments will be listened to, and will give feedback to the results obtained in the system model row.

4. **Reflection.** This last phase corresponds to a comparison between the unified information used to fill out the system model row, and the recommendations made in the observation phase to improve the system model row information. In other words, the stakeholders should carry out a comparative analysis to project the actual situation (AS-IS) of the system model information versus the recommended situation (TO-BE) for successful business performance (see Table 7).

<table>
<thead>
<tr>
<th>SYSTEM MODEL (LOGICAL)</th>
<th>DATA What</th>
<th>FUNCTION How</th>
<th>NETWORK Where</th>
<th>PEOPLE Who</th>
<th>TIME When</th>
<th>MOTIVATION Why</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results</td>
<td>Data Model (UML Class Diagram)</td>
<td>Applications Functions (UML Activity Diagram)</td>
<td>Nodes Functions (Connectivity Diagram)</td>
<td>Organisational Charts (with Responsibilities)</td>
<td>System Events</td>
<td>Business Process Rules</td>
</tr>
</tbody>
</table>

**Cycle 3 – Technology Model.** It consists in four phases to implement the technology model perspective of the Zachman framework. This perspective provides a physical representation of the IT infrastructure supporting the enterprise information systems operation (see Figure 3):

1. **Action-Planning.** This phase includes two activities:
   1.1 *Future work presentation.* It is convenient to carry out a meeting to explain the technology model row of the Zachman framework to the stakeholders. This meeting will help to clarify the kind of information that will be required to fill in this row. In this meeting, only the stakeholders that were selected according to the responsibility assignment matrix should participate by providing the information required to fill out the technology model row.
   1.2 *Information collecting tool analysis.* In this activity, questionnaires are still the best tool to collect all the information required to better understand each one of the cells of the technology system model perspective. Furthermore, this activity helps the computer systems analysts and other stakeholders to select the proper information and communication technologies (ICTs) to support and guarantee the optimal performance of the business operation.
   - **Technology Model Questionnaire:**
     - What (Data). What data model is used in the enterprise and if this data model is the most proper one? If the answer to the latter question is no, justify. Indicate what type of database the enterprise uses, which DBMS, if the database is centralized, how data is replicated (if it is done), what security policies are managed, how data and information is secured?
     - How (Function). What technologies support the enterprise business processes?
     - Where (Network). What type of communication technology does the enterprise have to perform information transfer processes? Which communication tools (instant messenger, e-mail, etc.) are installed? How is the information distribution/transfer managed?
     - Who (People). Who are the stakeholders of each one of the enterprise business processes? How is the information flow between the stakeholders (e.g. on-time, accurate, etc.)?
     - When (Time). How are the phases or cycle activities (develop, maintenance, control) of the components/systems used by the enterprise controlled? Regarding enterprise databases, what transactions are performed in these databases?
     - Why (Motivation). List the analysis and design rules implemented by the enterprise technology department, what action-taking applies to the resolution of a problem or errors? What assignment rules and evaluation performance of the same one are realized?

2. **Action-Taking.** This phase include four activities:
   2.1 *Questionnaire application.* According to the responsibility assignment matrix, the questionnaires should be applied to the corresponding stakeholders.
2.2 Results analysis. The information obtained from questionnaires applied to the stakeholders involved in filling out the technology model row should be compared with that obtained from the enterprise documentation (scope model row) to make conclusions between both models and unify the information collected.

2.3 Fill out the technology model row. Once the information of the questionnaires and the enterprise documentation has been unified, the next step is to fill out the corresponding cells of the technology model row with the proper information. Most common modelling tools for the information representation/documentation of the technology model row are presented in Table 8.

<table>
<thead>
<tr>
<th>TECHNOLOGY MODEL (LOGICAL)</th>
<th>DATA What</th>
<th>FUNCTION How</th>
<th>NETWORK Where</th>
<th>PEOPLE Who</th>
<th>TIME When</th>
<th>MOTIVATION Why</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modelling Tools</td>
<td>Entity-Relation Model for Design Tables and Indexes</td>
<td>Structure Diagrams</td>
<td>Technology Network and Topology Models</td>
<td>Interface Users (Screenshots)</td>
<td>Master Schedule</td>
<td>-</td>
</tr>
</tbody>
</table>

2.4 Presentation of results. After filling out the technology model row, it is convenient to make a presentation to all the stakeholders involved in the phase, with the objective of presenting the results that are already projected in the framework.

3. Observation. The results presentation activity in the action-taking phase will represent the evaluation/observation phase, in which stakeholders’ comments will be listened to and will give feedback to the results obtained in the technology model row.

4. Reflection. This last phase corresponds to a comparison between the unified information used to fill out the technology model row, and the recommendations made in the observation phase to improve the technology model row information. In other words, the stakeholders should carry out a comparative analysis in order to project the actual situation (AS-IS) of the technology model information versus the recommended situation (TO-IS) for successful business performance.

Table 9. Information Modelling Results in the Technology Model Perspective used in the Case Study

<table>
<thead>
<tr>
<th>TECHNOLOGY MODEL (LOGICAL)</th>
<th>DATA What</th>
<th>FUNCTION How</th>
<th>NETWORK Where</th>
<th>PEOPLE Who</th>
<th>TIME When</th>
<th>MOTIVATION Why</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results</td>
<td>Databases Schemas</td>
<td>Systems Functions and Migration Rules</td>
<td>Node Functions</td>
<td>Users (Roles, Rights, Privileges) Information Flow</td>
<td>Gantt Graphics</td>
<td>Operational Conditions and Characteristics</td>
</tr>
</tbody>
</table>

By defining the technology model row, enterprises define their priorities for their technology infrastructure, policies, and choices that allow software, networks, hardware, and data sources to be integrated into a cohesive platform. These definitions help to form the business strategy for the correct IT alignment of the enterprise (Lufman, 2003). The advantage of defining the technology model comes from the appropriate application of IT as a driver or enabler of the business strategy.

7. Case Study: PyME CREATIVA

Based on the action-research methodology proposed in previous section (see Figure 3), a case study is presented as a way to validate the benefits and effectiveness of the methodology for the Zachman framework implementation in a real technology-based enterprise. The following paragraphs will give a brief introduction to the case study context and a short description about PyME CREATIVA: http://www.pymecreativa.com.

New ways of working in the global landscape demand that Small and Medium Enterprises (SMEs) use new business models to create value-added industrial networks (e.g. virtual industry clusters and virtual organisations) with the aim of sharing technological capabilities (e.g. skills or core-competencies and resources) to access new business opportunities in global markets. These value-added networks need to use integrated information services (e-services), which have to be integrated in an open technological platform known as the e-HUB (integrated e-services center for virtual businesses) to enable the coordination and collaboration among SMEs with the purpose of allowing them to share their knowledge and technological capabilities during the creation of virtual organisations (short-term coalitions), formed to answer a specific business opportunity (Molina et al, 2006).
PyME CREATIVA (for its acronym in Spanish: CREAción de Tecnologías de Información para redes industriales de Valor Agregado) is a project start-up enterprise whose objective is developing and integrating the necessary information and communication technologies to create an e-HUB (transparent, easy-to-use, and affordable plug-and-play ICT-infrastructure) to enable the interoperation among organizations and to support the creation of virtual organizations based on SMEs integration in value-added industrial networks (Molina & Flores, 1999).

PyME CREATIVA develops and offers electronic services (e-services) that support SMEs core-business processes such as: marketing, negotiation, supply, engineering and productivity. These e-services are integrated in a common technological platform (the e-HUB) that allows the SMEs (mainly from the manufacturing industry in the metal-mechanic and plastic sectors) to have access to vast amounts of technology that supports their business objectives with a cost-effective solution based on a Software-as-a-Service (SaaS) delivery model (on-demand e-services). *For more about PyME CREATIVA software architecture to offer e-services to SMEs, please see (Molina et al, 2006 and Espadas et al, 2007).

The following paragraphs will present the implementation of the Zachman framework in PyME CREATIVA using the action-research methodology proposed in this paper.

**Cycle 1 – Business Model**

1. **Diagnostic.** Luftman (2003) states that first understanding of business and IT should be assessed individually by a team of IT and business unit executives to determine the enterprise’s level of strategic maturity on the business model, being this the first activity for the PyME CREATIVA project. PyME CREATIVA currently has five e-services (e-marketing, e-negotiation, e-supply, e-engineering and e-productivity). These e-services are in a beta software development stage to receive feedback from a group of SMEs selected as beta testers to represent the final users’ interests and concerns. PyME CREATIVA stakeholders’ roles are the following: Project Leader, General Coordinator, Specialist Consultant, Technology Specialist, Software Development Specialist, Technical Unit Leader and SMEs Contact Specialist. For future commercialization activities, it has been considered to add a new stakeholder role named: Sales/Marketing Unit Leader. PyME CREATIVA infrastructure includes: high-speed Internet with access to Internet 2.0 and commercial Internet, videoconference and e-learning facilities with ISDN connection and IP Networks, software development laboratories, just to mention some ICT-infrastructure elements. In general, the diagnostic phase results include all enterprise documentation available describing the PyME CREATIVA enterprise model and its strategy.

2. **Action-Planning.** An analysis of PyME CREATIVA stakeholders was carried out to assess the importance of their participation in each one of the action-research methodology phases and activities proposed for the Zachman framework implementation (the project). Table 10 presents the assessment results highlighting the risk and decision-making power levels, and the importance of each stakeholder involved in the project.

<table>
<thead>
<tr>
<th>ID</th>
<th>Stakeholder Name</th>
<th>Risk</th>
<th>Power</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>Project Leader</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>002</td>
<td>General Coordinator</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>003</td>
<td>Specialist Consultant</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>004</td>
<td>Technology Specialist</td>
<td>L</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>005</td>
<td>Software Development Specialist</td>
<td>H</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>006</td>
<td>Software Development Specialist</td>
<td>H</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td>007</td>
<td>Technical Unit Leader</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>008</td>
<td>SMEs Contact Specialist</td>
<td>L</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>009</td>
<td>Sales/Marketing Unit Leader</td>
<td>L</td>
<td>L</td>
<td>H</td>
</tr>
</tbody>
</table>

**Level:**
- **H:** High (people who have the decision-making power and/or are responsible for the project’s management).
- **M:** Medium (people who are experts in the relevant project areas and are interested in participating in the project).
- **L:** Low (people who can contribute with their knowledge without being fully interested in the project).

The value assignment in Table 10 was basically made through assigning the risk, power and importance levels depending on the stakeholders’ participation in the project; in other words, depending on the collaboration and participation they will have in each row of the Zachman framework during its implementation.

The next activity was to create a Responsibility Assignment Matrix (RAM) where the stakeholders’ participation in each one of the action-research methodology phases and activities during the Zachman framework implementation was indicated. An example of the RAM results for the phase or cycle 1 (*business model*) is presented in Table 11.
Table 11. Responsibility Assignment Matrix (RAM) for Cycle 1 - Business Models

<table>
<thead>
<tr>
<th>Phase</th>
<th>Stakeholder</th>
<th>001</th>
<th>002</th>
<th>003</th>
<th>004</th>
<th>005</th>
<th>006</th>
<th>007</th>
<th>008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle 1 – Business Model</td>
<td></td>
<td></td>
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<tr>
<td>en1. Diagnosis</td>
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<td></td>
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<td></td>
<td>A</td>
</tr>
<tr>
<td>2. Action Plan</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 Stakeholders’ Analysis</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>A</td>
<td>P</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2 Future Work Presentation</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>A</td>
<td>P</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3 Information Recollecting Tool Analysis</td>
<td></td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>3. Action Taking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 Team Meeting</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>A</td>
<td>P</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2 Questionnaire Application</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>A</td>
<td>P</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3 Result Analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4 Fill Business Model Row</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>3.5 Result Presentation</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>A</td>
<td>P</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Evaluation/Observation</td>
<td></td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>5. Learning/Reflection</td>
<td></td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P = Participant
A = Responsible
R = Required for verification
O = Required for opinion

Action-planning helps to define an assessment process for the enterprise and it recognises such tasks that must be done with a team including both business and IT executives. Such tasks and their planning are extremely valuable in understanding the problems and opportunities that need to be addressed to improve business-IT alignment. By assigning specific tasks with clearly defined deliverables will drive specific actions that are appropriate to enhance IT-business alignment (Luffman, 2003).

3. **Action-Taking.** The first activity for this phase was to make a presentation to the PyME CREATIVA stakeholders to explain: What is the Zachman framework? What activities are going to be carried out for its implementation? What is going to be required from each stakeholder during their participation in the project’s phases and activities? The second activity was the application of questionnaires. The questionnaires corresponding to cycle 1 (context and business models) of the action-research methodology proposed and were sent through e-mail to the PyME CREATIVA stakeholders. Once their answers were obtained, the third activity was immediately started to validate the information to be used to fill out the context and business models rows cells of the Zachman framework with the specialists. At the same time, the fourth activity, organisation and proper modelling of the information obtained from the stakeholders before filling in the context and business model rows, was carried out. The fifth activity could be represented by Table 12 showing an example of the information used to fill each cell of the context model row or by Table 4 showing the information models used to fill in each one of the business model row cells.

Table 12. Zachman Framework Row 1 - Contextual Model (Example)

<table>
<thead>
<tr>
<th>DATA</th>
<th>FUNCTION</th>
<th>NETWORK</th>
<th>PEOPLE</th>
<th>TIME</th>
<th>MOTIVATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Open Source Information Technologies for the Project Development</td>
<td>Participation of the SMEs in at least one New Market</td>
<td>ITESM Campus Monterrey facilities at the Center of Innovation in Design and Technology in Monterrey, Nuevo Leon, Mexico</td>
<td>Computer Systems Analysts e-services Specialists</td>
<td>3 years of Operation</td>
<td>To increase SMEs Business Opportunities in Global Markets and to increase their Competitiveness in the Manufacturing Industry through New Business Models To create Value-added Industry Networks</td>
</tr>
</tbody>
</table>

Furthermore, Figure 4 depicts the function cell of the business model row and shows how the PyME CREATIVA e-services workflow works when a customer requests access through a Web interface (e.g. a Web browser) to the e-services that he/she will use by deploying the information available in the databases and the functions of each e-service. Figure 4 also shows how the e-services are integrated into the enterprise business processes.
Regarding the other cells of the business model row, their representations were diagrams like: <Data> entity-relationship diagrams (in business level), <Function> workflow diagrams (using business process modelling notation), <Network> logical network diagrams (networks location identification on geographic maps), <People> organisational charts (representing the business units), <Time> master schedules (Gantt graphics) and <Motivation> business objectives (strategic statements) (see Figure 8 for the complete diagram).

The primary objective of action-taking is to implement the tasks and recommendations defined in action-planning stage to improve the alignment of IT and the business. The enterprise, after assessing each of the tasks and models defined in action-planning, uses the results of action-taking to converge on an overall assessment level of the IT-business alignment maturity for the firm (Luftman, 2003).

Figure 4. PyME CREATIVA Workflow Diagram [Adapted from Molina & Medina (2003)]

4. **Evaluation/Observation.** The information assessment was carried out through a set of questionnaires that served as the collection tool of the information related to each of the cells that integrate the business model row. Through the presentation of the results obtained it was possible to acquire new feedback on the information that was already provided by the stakeholders involved in this business model cycle.

5. **Learning/Reflection.** Based on the information obtained through the questionnaires, it was possible to appreciate the need for a complete business model (row) definition, including the designation of roles and responsibilities of the stakeholders that will integrate the work team to achieve the business objectives. It is important to review the goals and regularly discuss the results and outcomes identified to evaluate the implementation of further action-planning. The review of the results and outcomes should serve as a learning vehicle to understand how and why the enterprise mission and goals are or are not being met (Luftman, 2003).

**Cycle 2 – System Model**

**Action-Planning.** The first activity in the system model cycle (see Figure 3) was to make a presentation to the PyME CREATIVA stakeholders about the system model row of the Zachman framework. The stakeholders invited to the presentation were determined according to the responsibility assignment matrix (see Table 10) in order to guarantee that the right people were present at the meeting to describe the information required to fill each of the cells of the system model row. The second activity was the analysis of the information requirements identified in order to assure that all information required will be recollected during the action-taking phase to properly fill out the system model row. This new iteration of action-planning helps to reach the strategic alignment maturity assessment defined by Luftman (2003) as an important tool for understanding the business-IT linkage.
1. **Action-Taking.** Questionnaires regarding the *system model row* were sent through e-mail to the selected PyME CREATIVA stakeholders as the first activity in the action-taking phase to collect all the information required to fill in the *system model row cells*. Secondly, all information gathered was organised, modelled and validated with the specialists, to use it in the third activity by filling in each cell of the *system model row*.

Furthermore, Figure 5 depicts the *network cell* of the *system model row* and shows the connectivity diagram of the PyME CREATIVA e-HUB architecture with the integration of the e-services offered to the users. Figure 5 also shows that the principal way to make a request and get a response is through Internet, using a Web browser or a handheld device, and this request is going to be processed by a Web portal (the eXo platform).

This new iteration of action-taking helps to understand resources, technologies, infrastructure, software components and architectures in order to recognise the gap between where the enterprise is today and where it believes it needs to be. The purpose of this step is to understand the activities necessary to improve the business-IT linkage (Luftman, 2003).

![Diagram](image.png)

**Figure 5.** e-HUB Connectivity Diagram including e-Services (Adapted from Molina et al, 2006)

Regarding the other *cells* of the *system model row*, their representations were diagrams like: <Data> UML class diagram (for data models), <Function> UML activity diagrams (showing the interaction between processes and their elements), <People> organisational charts (with responsibilities assigned to the business units), <Time> software development lifecycle model (representing the software development process and its stages) and <Motivation> e-services integration to SMEs manufacturing business processes diagram (business process rules) (see Figure 8 for all cells diagrams).

2. **Observation.** After the *system model row* was filled, a presentation of the results obtained was made to the PyME CREATIVA stakeholders to assess the information gathered and used to fill in the row. Through the presentation of the results obtained, new feedback was provided by the stakeholders involved in the *business model cycle* to improve the information modelled.

3. **Reflection.** As a result of the information analysis activity and the reflection phase, a diagram was created to represent the information of the *motivation column* where the SMEs’ business processes were covered by the PyME CREATIVA e-services. After this representation the diagram was modified to separate the quality assurance process out of the SMEs business processes (see Figure 6).
By continuously making observations and reflecting on the planning and actions, enterprises can increase their potential for a more mature alignment assessment and improve their ability to gain business value from investments in IT. Hence, the continued focus on understanding the EA business processes for an organisation and taking the necessary action to improve the IT-business harmony is key (Luftman, 2003).

![Diagram of business processes]

**Figure 6.** PyME CREATIVA e-Services Integration to SMEs Business Processes

**Cycle 3 – Technology Model**

1. **Action-Planning.** The first activity in the *technology model cycle* (see Figure 3) was to make a presentation to the PyME CREATIVA stakeholders about the *technology model row* of the Zachman framework. The stakeholders invited to the presentation were determined according to the responsibility assignment matrix (see Table 9) to guarantee that the right people were present at the meeting to describe the information required to fill in each of the *cells* of the *technology model row*. The second activity was the analysis of the information requirements identified in order to assure that all information required will be collected during the action-taking phase and thus properly fill out the *technology model row*. Action-planning at this step should also include all considerations related to human resources for the enterprise. Going beyond the traditional considerations such as training, salary, performance feedback, and career opportunities. These are factors that include the enterprise cultural and social environment. According to Luftman (2003), these are several important qualities of mature organisations.

2. **Action-Taking.** Questionnaires regarding the *technology system model row* were sent through e-mail to the selected PyME CREATIVA stakeholders as the first activity in the action-taking phase to collect all the information required to fill out the *technology model row cells*. Secondly, all the information gathered was organised, modelled and validated with the specialists, to then use it in the third activity to fill in each *cell* of the *technology model row*.

   Furthermore, Figure 7 depicts the *data cell* of the *technology model row* and shows the database structure that supports the information required by the e-marketing, e-negotiation and e-supply e-services.
Regarding the other cells of the technology model row, their representations were diagrams like: <Data> database schemas (tables and indexes), <Function> UML sequence diagrams (systems functions), <Network> network topology diagram (nodes functions), <People> users (roles, rights and responsibilities), <Time> project timeline (Gantt graphics) and <Motivation> operational conditions and characteristics (see Figure 8 for the complete diagram).

3. Observation. After the technology model row was filled, a presentation of the results obtained was made to the PyME CREATIVA stakeholders to assess the information gathered and used to fill in the row. Through the presentation of the results obtained, new feedback was provided by the stakeholders involved in the technology model cycle to improve the modelled information.

4. Reflection. As a result of the information analysis activity and the reflection phase, a diagram was created to represent the information of the network column where the PyME CREATIVA network topology was depicted in high detail describing the technological platform with its databases, applications and mail servers to back up the enterprise information and protect it against failures and/or shutdowns. An important consideration in the reflection step is the creation of technological recommendations addressing the problems and opportunities identified (Luftman, 2003). Filling in the technology model row is an important mechanism to improve specific alignment for IT infrastructure and the business processes carried out by the enterprise.
8. Lessons Learned

Using the action-research methodology proposed in this paper to leverage the Zachman framework implementation can allow enterprise architects to keep a detailed track of the activities to be carried out for its implementation, improving in this way the project management for the framework implementation.

During the Zachman framework implementation - in the case study presented, by following the action-research methodology proposed, it was possible to clearly define the involvement of each stakeholder during each of the three action-research cycles (business, system and technological rows of the Zachman framework), allowing in this way to the enterprise architects to limit the stakeholders participation only when needed and letting the stakeholders to continue working in their usual daily activities during the framework implementation. This represents a significant advantage of the action-research methodology proposed from a project management point of view, since the methodology reduces the disturbances in the daily business operations of an enterprise during the Zachman framework implementation and reduces as a result the resources needed to be allocated for this task (men-hours).

By leveraging the Zachman framework implementation using the action-research methodology proposed, it was possible to visualise in the case study presented the enterprise business goals in a complete and holistic way, allowing the implementation of successful organisational structure.

Using the Zachman framework for aligning the enterprise architecture to the business goals of a technology-based enterprise, allows the enterprise architects and stakeholders to graphically represent the different entities - and their interrelations - that conform an enterprise (data, functions, people, network, time and motivation), offering in this way different viewpoints (scope, business model, system model, technology model and detailed representations), according to each stakeholder’s role (planner, owner, designer and builder), to collaboratively define an organisational structure to improve the business performance and support the business goals achievement.

9. Conclusions & Further Research

Enterprise Architecture (EA) frameworks implementation is a complex task. Commonly, the EA frameworks provide the necessary tools and schemes to organise and document the whole enterprise. Nevertheless, the implementation becomes difficult without an established path to follow or without practical methods about how to develop the enterprise architecture. Furthermore, this task becomes more difficult in small enterprises or start-ups that base their business’ value in technological assets, commonly
known as “technological-based enterprises”. This paper proposed the implementation of the Zachman framework combined with an adapted action-research methodology in order to assist and facilitate the establishment of the enterprise architecture and to provide a practical path of an EA implementation.

An action-research methodology was proposed for carrying out the implementation of the business, system and technological models of the Zachman framework in a technology-based enterprise. This proposal is composed of three cycles corresponding to the business, system and technological rows of the Zachman framework, and in each phase of the cycles, it can be appreciated an internal cycle of those activities that should be carried out respecting the action-research phases. The model adapts the nature of the action-research methodology by modifying the spiral order of the improvement cycle according to the methodology proposed, which can be made upon finishing a cycle or going back from the present cycle to the previous cycle to make the pertinent improvements. The improvements can be done or the cycle can be executed \( n \) number of times until the expected results are obtained. The jump to a previous cycle will be only possible to the immediate previous cycle, as this is one of the rules that Zachman indicates for implementing his framework.

The result of combining the Zachman framework with the action-research methodology proposed as demonstrated in the PyME CREATIVA case study was a step-by-step methodology to obtain the correct and complete information to fill in all the cells of the Zachman framework. The action-research methodology proposed allows for obtaining a framework that permits visualizing the PyME CREATIVA enterprise architecture in a complete way, to be able to know the scopes, objectives and stakeholders involved in each of the stages and elements that shape the enterprise.

Further research goes into the direction of the unification of all the Zachman Framework cells under the same modelling language (e.g. UML).

## 10. Contributions to Enterprise Integration & Enterprise Modelling

Enterprise Integration (EI) and Enterprise Application Integration (EAI) aims to enhance the Enterprise Architecture capabilities of an enterprise to become a more agile, flexible and robust in order to achieve both technical and behavioural integration for a greater degree of communication, coordination and cooperation among human actors as well as information systems (Lee et al, 2003; Liu et al, 2008; Espadas et al, 2008). Following such integration principles, this paper proposed a new methodology based on action-research for the implementation of the business, system and technology models of the Zachman framework to assist and facilitate its implementation as an Enterprise Architecture Framework for small-technology based enterprises. The action-research approach proposed may be considered as a novel EI / EAI methodology based on an Enterprise Modelling strategy that considers technical and behavioural implications thanks to different stakeholders’ roles and perspectives provided by the Zachman framework. Authors hope that this research work provides a contribution to Enterprise Modelling driven approaches for achieving EI and EAI.

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## 12. References


1 A technology-based enterprise is defined as an organisation that bases its business’ value in the strategic deployment of its technological and/or knowledge assets, making critical the cohesive alignment between its IT infrastructure and its business model to leverage its competitive strategy.
2 An enterprise information system is any software or application that enables an organisation to integrate and coordinate its business processes (e.g. ERP, CRM, SCM).