

## **THE DEVELOPMENT OF AN ENTERPRISE RESOURCE PLANNING SYSTEM (ERP) FOR A RESEARCH AND TECHNOLOGY INSTITUTE: THE CASE OF THE NUCLEAR AND ENERGY RESEARCH INSTITUTE -IPEN**

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### **ABSTRACT**

This paper reports the history of the development of an enterprise resource planning (ERP) dedicated to managing the technical activities of the Nuclear and Energy Research Institute, a governmental research and technology institute in Brazil. After the implementation of the new planning process, the development of a new management information system named SIGEPI was immediately initiated. The implementation of this system followed a strategy of integrating databases already available and developing new ones in order to facilitate the data collecting process and to improve the quality and the reliability of these data. This paper describes the evolution of SIGEPI, its main features and it also reports the difficulties faced for almost ten years of developments. The success factors of the case were classified into three groups: strategic, technical and behavioral ones. The impact of these factors and recommendation for future similar developments are presented.

**Keywords:** Integrated information systems, research and technology organizations, knowledge organization management, enterprise resource planning, management information systems.

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## **1. INTRODUCTION**

Managerial Information Systems (MIS) are systems dedicated to monitoring and controlling an organization. Literature about the experience of developing MIS in the context of R&D organizations is very scarce. In Brazil the only case so far identified in the literature is the EMBRAPA case – a top Brazilian R&D organization in the agriculture field. This case reported that the design of MIS is affected by impulsive factors (e.g.: innovative conceptual design, managerial sponsoring, performance and lack of integration of the preexisting information systems, strong external information demand for the R&D activities and communication between coordination and users) and restrictive factors (e.g.: innovation perception as a threat or reworking efforts, concurrence with other information systems being implemented, lack of managerial sponsorship, size of the developing team, negative attitude due to previous information systems experiences and complexities introduced by the system (Castro, Lima, Carvalho, & de Bacarin, 2000)).

The aim of this paper is to describe and analyze 10 years of experience developed by a Brazilian nuclear R&D Institute in the design and implementation of a special category of MIS known as Enterprise Resource Planning (ERP). This system manages the activities of more than 1,000 workers and 700 students and is named Planning and Managerial Information System of the IPEN (SIGEPI). It has been developed to support the management of the Master Plan of the Nuclear and Energy Research Institute (IPEN).

This article is organized with the following structure: the first section presents a brief literature review related to the management information systems implementation and the contributions of the present study; the second section presents the case of IPEN - this experience will be described in terms of how this system was developed, which features were implemented, the main difficulties faced during the development stages and recent developments; the third section analyses the experience related to the three critical factors (strategic, project design and implementation and behavioral) and presents recommendations for similar developments and the last section presents the conclusion and the final remarks derived from the case.

## **2. LITERATURE REVIEW**

Management systems can be classified into managerial support systems (MSS), management information systems (MIS) and decision support systems (DSS). The first one is dedicated to long term planning; the second and the third ones are dedicated to a shorter time period and they function as a monitor and control of the organization; the third one is specifically dedicated to non structured problems (Laudon & Laudon, 1999).

A special category of management information systems is that one dedicated to integrating an organization's business processes. Different names of the software packages for these management systems can be found in the literature: enterprise

information system (EIS), enterprise resource planning (ERP), enterprise-wide information systems (EWIS), enterprise systems (ES) (Looman & McDonagh, 2005).

ERP is a packaged software solution that seeks to integrate the complete range of a business process and function in order to present a holistic view of the business from a single information technology architecture although some experts have some difficulty arriving at a complete definition of ERP - they tend to think that ERP is 'in the eye of the beholder' (Klaus, Roseman, & Gable, 2000).

The main features of ERP-software are the provided business solutions, which support the core processes of the business and administrative functionality and purport all business functions of an enterprise. ERP supports recurring business processes like procurement, sales order processing or payment processes and is not focused on less structured irregular processes like marketing, product development or project management. An ERP can target multiple industries with very different characteristics. Some suppliers can provide specific solutions for the communication, federal government, financial services, healthcare, higher education, manufacturing, public sector, retail, service industries, transportation and utilities sectors (Klaus, Roseman, & Gable, 2000).

In the past, companies first decided how they wanted to do business and then chose a software package that would report their proprietary processes - often rewriting large portions of the software code to ensure a tight fit; with the enterprise systems, though, the sequence is reversed and the business often must be modified to fit the system (Davenport, 1998).

After studying more than 50 businesses with enterprise systems, Davenport suggested that "the companies deriving the greatest benefits from their systems are those that, from the start, viewed them primarily in strategic and organizational terms. They stressed the enterprise, not the system" (Davenport, 1998).

An EIS implementation process frequently does not succeed as expected. A survey conducted in December 2000 called 'EIS Post Implementation Issues and Best Practices' among 117 firms across 17 countries concluded that only 34 per cent of the organizations were 'very satisfied' with their EIS investments (McNurlin, 2001).

The ERP system is considered a standard software package and all standard software targeting an anonymous market must, during the process of system deployment, be tailored to the specific requirements of the individual enterprise (Klaus, Roseman, & Gable, 2000). This aspect associated with the relatively low satisfaction level mentioned earlier may explain the importance many studies have attributed to the identification and classification of an ERP implementation success and/or failure factors.

Loonam and McDonagh reviewed the literature between 1999 and 2001 and identified some of the most frequently cited and highly critical EIS implementation success factors: a) Top Management support; b) The importance of a project champion to drive project implementation and his role in the change management; c) User training and education; d) Management of expectations: an organization should be realistic about what can be expected from the EIS system; e) Project Management: involves

aspects like proper management of the scope and alignment of its objectives with the overall mission and strategy; f) Steering Committee (a core of ‘superusers’ – typically middle-level employees or managers that will be affected by the EIS project); g) Use of consultants to assist in getting the project up and running; h) Business Process Reengineering: involves aligning the implementation of an EIS with the rethinking or the redesign of the organizational business processes; i) Dedicated resources: involves the proper allocation of resources – human, financial and time – and the attention to the management scope; j) Change management: involves all human, social-related and cultural change techniques needed by the management to ease the transition (Looman & McDonagh, 2005).

In 2006, Muscatello and Chen (Muscatello & Chen, 2008) surveyed 206 members (81% with more than 500 employees) of four USA associations (the American Production and Inventory Control Society; the National Association of Accountants; the American Productivity and Quality Center and the Institute for Supply Management) in order to identify critical factors of ERP implementation. Some of these factors are similar to those identified by Loonam and McDonagh, thus, for the present study the following factors were considered: a) The decision to implement an ERP system is being made at a cross functional executive level which includes inputs from all functional business areas; b) willingness to use consultants to supplement their Information Technology staff if the skill set is not internal; c) activate employees communication: how they fit into the new ERP-environment and what their concerns are.

Finally, the ERP design and implementation may also be affected by the decision of outsourcing it or not. This decision may be influenced by the following factors: a) internal production costs versus market acquisition costs comparison; b) transactions costs; c) financial slack: organizations with financial slack may build an internal technology infra-structure; organizations without it may outsource it; d) strategic dependence on the supplier; e) contract profile orientation: open contract and partnership versus detailed contract and price oriented and f) organizational strategic objectives. These objectives can be classified into three categories: (i) information technology improvement, (ii) information technology business impact and (iii) commercial exploitation bases on information technology (Bergamaschi & Reinhard, 2008).

## **2.1 THE CONTRIBUTION OF THIS STUDY**

The proliferation of ERP systems happened in the 1990’s and one reason for this growth was the Year 2000 problem which caused many companies to replace their outdated systems with a more modern technology (Grossman & Walsh, 2004). Consequently the main literature concerning ERP systems has focused on the experience of customization and implementation of integrated commercial software packages purchased by the companies interested and very little attention was given to specific niches where the fit of these commercial packages would be low.

One these niches refer to the Research and Technology Organizations (RTO). The literature concerning MIS/ERP application in this niche seems to be very limited.

Except for the Brazilian Agricultural Research Corporation (EMBRAPA) case (Castro, Lima, Carvalho, & de Bacarin, 2000), most MIS experiences identified in the literature focus on specific MIS modules (e.g.: Laboratory Information Management System (Rasmussen, Maddox, Harten, & White, 2007) or the management of technical information (Chun, 2003)).

The present paper reports and analyzes the experience of an ERP design and implementation in an RTO from the author's perspective, and the persons who were directly responsible for the development of ERP. Thus, strictly speaking, this case study did not follow the methodology as recommended in the literature (Yin, 2004; Martins, 2006); instead it was written to present the reader with a detailed historical view on why and how this managerial information system was designed and implemented. It also gives some practical recommendation on how to overcome the difficulties faced during this process. It is expected that sharing this experience will contribute to the knowledge dissemination concerning non standard ERP software package implementation and encourage other knowledge organizations to properly manage the factors that may leverage or hinder their ERP design and implementation.

### **3. THE CASE OF THE IPEN**

#### **3.1 SOME WORDS ABOUT IPEN**

The IPEN (Nuclear and Energy Research Institute) is an organization that reports to the Development Department of the State of São Paulo and to the National Nuclear Energy Committee (CNEN), an organization of the Brazilian Science and Technology Ministry. The latter is directly responsible for the financial support of the IPEN. The IPEN is also associated, for teaching purposes, with the University of São Paulo.

The IPEN was established in 1956 and, as its mission, is committed to the improvement of the Brazilian population quality of life, to the scientific knowledge production, to the technology development, to products and services generation and to the development of human resources in the nuclear and correlated areas. In 2008, the permanent working force was composed of 1,029 individuals, where 219 of them were doctors and 118 masters. The revenue in 2008 reached about US\$ 30 million, mostly due to production and commercialization of products supplied to the nuclear medicine industry.

#### **A brief history of the organizational management learning process**

The IPEN started its management improvement process in 1996 when it decided to obtain the ISO 9002 certification process for the radiopharmaceutical and radioisotopes production system. In 1998, it adhered to the Excellence in Technological Research Project coordinated by the Brazilian Research and Technology Association (ABIPTI), a project in which the organization management improvement is based on National Quality Award (which is similar to the Malcolm Baldrige Award, from the

United States). By adhering to this project, the IPEN wrote its first management report based on the Excellence Criteria and identified, as well, its main deficiencies in management activities, namely, lack of appropriate customer satisfaction surveys, interrupted planning activities, absence of an organizational process to evaluate the working force satisfaction and absence of an organizational information system dedicated to monitoring and evaluating its main technical activities.

### **Antecedents of the MIS development**

The experience of writing the first managerial report following the Excellence Criteria in 1998 pointed out clearly the need to improve the quality of the information about what the organization was accomplishing yearly. In order to solve this problem one of the first decisions was the development of the software dedicated to the data collecting and gathering of all technical graduated individuals of the IPEN, data which, until then, was being collected and gathered through paper forms.

The IPEN has a technical staff for the development of information systems, thus the design and implementation of an application to operate on their internal website was initiated using this internal team. After more than 500 work hours, this project suffered a backlash: after a presentation to the IPEN's top management team, they concluded that the project would not properly solve the problem that the IPEN was going through. According to the perception of the Administrative Director, the institutional results could not be obtained by just adding up individual results. Besides, this director argued that the proposed method would reinforce the individualization of the research and development activities, while, in fact, the aim should be just the opposite: institutional practices that promote team work. Despite conceptually correct, the first consequences of such a decision were devastating to the technical team involved in the project: frustration and interruption of the development of this MIS which until then had lasted almost two years.

The restart of designing the activities of a conceptually new MIS only happened two years later, with the creation of the first Master Plan.

### **The Master Plan**

In 1998, the CNEN (National Nuclear Energy Committee) started and developed a two step planning process named "Rethinking the CNEN". The objective of the first phase was achieved, which was the outline of the mission, vision and other strategies, but, two years later, the second step - addressed to identify its main stakeholders and to unfold the planning process to the CNEN's research and technology institutes - was discontinued.

In 1999, after the internal analysis of an independent evaluation of the first Managerial Report written in reference to the Excellence Criteria of National Quality Foundation, the deficiencies of the planning process became clear: "we cannot go ahead with half strategic planning. Without it (a strategic plan), we will continue to spend energy without the synergy of our internal actions" (IPEN, 1999).

By the end of 1999, a wide managerial participation program was developed, which resulted in the first Master Plan of the IPEN in 2000 (IPEN, 2000). With the accomplishment of this process, the creation of the first Master Plan resulted in many changes or in new activities:

- Reorganization of the technical activities in alignment with the recently defined IPEN's mission;
- Definition of the Global Strategic Objectives and organization of a hierarchical and nested structure of Programs, Subprograms and Activities according to the Federal Government Plan (PPA)
- Definition of a new organizational structure based on Research Centers;
- Definition of three macro processes:
  1. Research, Development and Engineering;
  2. Teaching
  3. Products and Services;
- Different emphasis on one or more of these macro processes from one Research Center to another according to their internal strategies;
- Definition of quantitative results indicators for each of these macro processes as well as goals for some of them;
- Organization of an annual follow-up process named Master Plan Seminars.

The first Master Plan Seminar was held in December 2000 and since then it has been repeated annually. At that time the event was organized in 109 technical presentations that demanded 5 whole days to succeed. All the presentations had to be made in 15 minutes by an Activity coordinator following a predefined Power Point template where the qualitative and quantitative results accomplished in 2000 should be presented. Since then, many modifications have been introduced to the process, and some of them will be described later.

Almost at the same time, in 2000, the section responsible for structuring and implementing the IPEN's Master Plan also initiated the study of the Balanced Score Card methodology. Initially the idea was to understand this methodology and its implication for the IPEN's strategy formulation process. The BSC is quite easy to be understood and in the next year a Strategic Map for the IPEN was already developed, proposed and approved by the IPEN's Top Management Team. The development of this Strategic Map and its respective "Board Panel" helped to identify which processes should be monitored and stressed the need to integrate the data coming from the support processes.

### 3.2 DEVELOPMENT OF AN EFFECTIVE MIS

#### The demand

Credibility is a fundamental aspect of an effective planning process and one basic aspect involves the management of reliable data. After the first planning – evaluation cycle, the weaknesses of this process became apparent. The Power Point presentations were operating as information systems – the data were collected and presented using the Power Point template – and many of the problems could be easily detected: lack of a common understanding of many indicators, same information showing up in different presentations, repetition of results previously presented as well as difficulties in collecting the data and in preparing the presentation.

In order to solve these problems, the design of an information system was initiated and named as Planning and Managerial Information System of the IPEN (SIGEPI). Despite the difficulties faced in the first MIS development experience, the perception of the section responsible for the Master Plan and the Master Plan Seminar was that such a system should be preferably designed and implemented – at least at the beginning of the project - by internal resources of the IPEN, due to the specificities and uncertainties involved.

#### The development

The beginning of SIGEPI's design was inspired by another Managerial Information System developed by one of the IPEN's Research Centers, the Nuclear Engineering Research Centers (CEN). Although the scope, focus and deepness of both MISs were distinct, some functional similarities were clear: 1) same Plan-Do-Check-Action principle; 2) Easy learning capabilities offered by the MS-ACCESS software and 3). Low human resources demand: only one graduated professional from the Nuclear Engineering Research Center staff was enough to develop the whole information system.

Considering the previously failed experience and the CEN's experience, an engineer involved in both Master Plan organization and Master Plan Seminar process was allocated to design and implement the first SIGEPI-ACCESS version instead of involving someone from the System Development Section. In December 2001, six months later, the first version of the new MIS was created.

The initial expectations about this system were high: it was expected that the software would operate through their Intranet. The link to the main database was installed at least in one computer in each Research Center of the IPEN. The functionalities and procedures of the new system were formally presented to the managers and researchers of all Research Centers and the secretaries of each Research Center were trained to operate the system. An operating manual was also written to help the system users. But the promise did not come true: the screens of this version were not user friendly and to make matters worse the system did not operate properly using the Intranet. Due to these problems there was a backlash and we had to collect all the data using paper forms. All the data gathered were then inserted by the Planning Section into

this SIGEPI-ACCESS version instead of being inserted by the Research Centers staff.

The development of the Balanced Score Card mentioned earlier and this initial experience brought some important insights. From one perspective, the poor data quality problem was not solved, but from another perspective we identified that some information that should have been collected and presented by the Research Center during the Master Plan Seminar was already available among the supporting sections of the IPEN. In 2001 some of the IPEN's support processes were still being carried out manually – (e.g.: patent processes), others were already computerized (e.g. budget) and others were being designed and modernized in terms of computerized databases (e.g.: library services, post-graduation support services). It became clear though that all these databases could be integrated in order to have a “full” MIS system and maybe, most importantly, we learned that such a system should be used to work for the staff and for the organization and not the other way around.

The SIGEPI-ACCESS version operated until 2004, when it became clear to the top management team that there was a need to upgrade the present institutional MIS version. At that time, with all the previous experiences, we knew exactly what was necessary in terms of relational databases and information content; thus, with the support of the top management team, the system development team reengaged in the unfolding of a new and then a real enterprise resource planning (ERP).

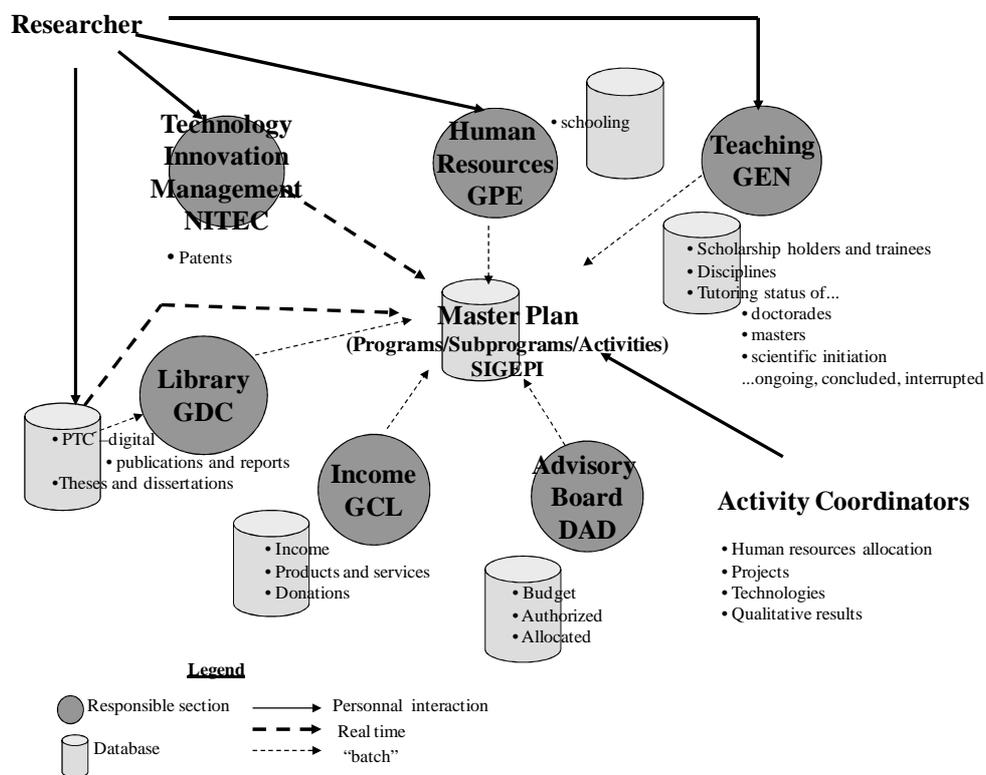
At that point an important decision needed to be made concerning the ERP design and implementation: outsource it or not?

This concern was clearly expressed to the internal software development team. Both alternatives would receive support from the management director and the planning director. The managing director had a preference for outsourcing due to the success of an previous experience in budget system. The system analysts involved in this process were inclined to develop the new ERP by themselves – despite the fact that the programming language they were familiar with was not the most appropriate, the challenge of developing such a system was very attractive, though; thus, the design and implementation did not have to be outsourced.

With the support of the manager of the System Development Section, three system analysts were fully allocated to write a web ERP version. After six months and under a lot of pressure to finish the system by the end 2004, a fully new ERP named SIGEPI-WEB was finished and implemented with many new functional and databases integration facilities (income, budget, patents, post-graduation results – ongoing, concluded and interrupted master essays and doctorate thesis - publications and personal educational level data). The immediate benefits were crystal clear: less data were demanded from the technical areas and the data quality reached an unprecedented level.

Figure 1, presented below, represents the data flow dynamics as well the databases integration that drives the SIGEPI-WEB ERP operation. As it can be observed, some sections (gray circles) are responsible for the data of the processes under their responsibilities. Researcher and Activities Coordinators are the data source of the information under their responsibility and supplied by themselves. The researchers need: 1) to supply what they have published to the library section using the

PTC-digital (a special database designed to be integrated with SIGEPI-WEB); 2) to interact with the NITEC in order to initiate and follow a patent deposit process; 3) to inform their scholarship level changes to the Human Resources Section and 4) to sign up their students through the teaching section. The Activities Coordinators need to enter all the projects the group is responsible for, as well as the results of these projects. In a few words, the data gathering from the support processes, the data supplied by the researchers and by the Activities Coordinators allow the management of the Master Plan.



**Figure 1: databases integration logic and data flow of SIGEPI-WEB<sup>1</sup>**

Three months after the new version of the system was launched, two additional features were introduced into SIGEPI-WEB which also helped to improve the perception of the benefits of such a system:

1. Automated generation of Power Point presentations for the Master Plan Seminar: the system generates the “hard” data part of the presentation by automatically retrieving and generating the slides based on the qualitative and quantitative data inserted into the SIGEPI-WEB database. The Activities Coordinator responsible for a presentation is free to dedicate his time to the “intelligent” part of the presentation;

2. Quantitative indicators integration and aggregation: The main quantitative results of the IPEN now can be monitored by the whole work force under diverse integration and aggregation criteria – and some of them in real-time: Institutional, Research Center, Program, Subprogram and Activities. Some results (e.g.: publications) were carried out by internal partnerships - these partners may be connected to different Activities, Subprograms, Programs or Research Center. The same result is properly credited to each of these aggregation levels, but institutionally they are not counted repeatedly.

### **Main SIGEPI functionalities**

SIGEPI-WEB, or just SIGEPI, is an ERP which operates in two sequential states: “planned” and “accomplished”.

The “planned” operation mode has the objective of collecting the planning data defined by the coordinator of one Master Plan Activity for a one year time span.

Figure 2 shows the entrance screen with all the links that one coordinator has made available to plan the Activity under his or her responsibility. This entrance screen is unfolded into six data groups: 1) Activity: basic information describing what the Master Plan Activity is about; 2) Human resources: the allocation time can be planned according to the different scholar profile team that can be connected to the Activity; 3) Qualitative results: brief description of the main projects marks and final results expected to be accomplished; 4) Teaching Function: the expected results from disciplines and orientation effort; 5) Research, Development and Technologies expected results: publications, technologies and patents and 6) Product and Service Function: expected results for commercial activities as well as for internal support activities. On the top of these six blocks, some special links are available: help, concepts, Activity planning (or “accomplished”, depending on the operation mode) preview extract, planning pending data and quantitative indicators panel.

In order to facilitate this planning process, the last year’s results of the quantitative data are shown, so the previous information can be used as a reference for the incoming year’s goal projections. For some of the regular products and services quantitative projections can be easily calculated just by entering one increase rate field and all the expected results will be automatically updated. In the case of teaching results - master and doctorate students - the system automatically calculates the conclusion date based on the deadline these students are going to obtain their degree – the Activities Coordinator may accept this suggestion or modify it. In the case of the qualitative data, the system automatically retrieves the data from the last year “on going” status, so there is no need to insert them again.

Once the planning process is finished, the system mode is connected to the “accomplished mode”. The screens available are basically the same, but in the accomplished mode some of the displayed data are based on the databases managed by the supporting areas as described in Figure 1.

**SIGEPI - Accomplishments / 2009**

Coordinator: PAULO ERNESTO DE OLIVEIRA LAINETTI

Unit: CQMA

Activity:

510 - Clean technologies

04/09/2009 12:56:51 h

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[Help](#) | [Accomplishments summary](#) | [Pendencies](#) | [Indicators](#) | [Conclusion](#)

<b>Activity</b> Basic information	<b>Human resources</b> Ipen staff Students Outside participants and volunteers	<b>Main results</b> Qualitative results
<b>Teaching Function</b> Disciplines Tutoring	<b>R&amp;D and Engineering Function</b> Financial resources Documented products Technological products Clients Partners Patents	<b>Product and Services Function</b> Financial resources Income New catalogue products Catalogue Products and services - quantities Products and services - quantities controlled by the Unit Clients

**Figure 2: SIGEPI entrance screen example for one Activity coordinator after logging into the “accomplished mode”**

SIGEPI – Planning and Information Management System of the IPEN



Master Plan - accomplished in 2009

Select the year

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04/09/2009 09:56:36

<b>Activity</b>	240 - Radiation applications in the industry and environment
<b>Basic Information</b>	Indicators
<b>Technical and Scientifical Production</b>	Unit Summary Activity Summary
<b>Tutoring</b>	Unit x Level - on going, concluded e closed Activity x Level - on going, concluded e closed Activity x Level
<b>Disciplines</b>	Unit x Level Activity x Level
<b>Tecnologies</b>	Unit x Tecnology type Activity x Tecnology
<b>Active Projects</b>	Summary Concluded on the selected year or on going - detailed report Financial resources - received and programmed - detailed report finished at end of the year or previous years - updated current year
<b>Revenue</b>	Revenue - Figures and Production Quantities per Activity Donation - Figures and Production Quantities per Activity
<b>Indicators</b>	IPEN 1 - Radiopharmacy per Program New Radiopharmacies per Subprogram CB - Biotechnology Center per Unit

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**Figure 3: screen displaying the different result report categories**

SIGEPI provides several categories of reports. Most of these reports are concentrated in one screen, as presented in Figure 3. Eight categories of reports are available: 1) Activity; 2) Technical-and-Scientific production; 3) Tutoring; 4) Disciplines; 5) Technologies; 6) Active projects; 7) Revenue and 8) Indicators. In almost all of these report groups, additional criteria are available when the link is accessed, thus allowing for refined information access.

### **Implementation difficulties and recent improvements**

The implementation of an ERP does not run smoothly; in the case of SIGEPI it was not different. Firstly, as mentioned earlier, when the ERP design was restarted in 2004, the system analysts involved in the project had the knowledge that it was “enough” but not state of the art.

Thus it was known that the system could face some performance limitations. Secondly, immediately after the new ERP was released on the Intranet, the server where the program was installed presented unexpected problems – to solve the problem a server computer was fully dedicated to operate SIGEPI; thirdly, as soon as the users began to access the data derived from supporting databases, they immediately started complaining about the quality of data: many of them were incomplete or wrong. When the databases are integrated, it is expected that they are correctly updated. In some cases they were not and exposed their managers to criticism. Instead of observing the benefits – in the short and long term – the immediate reaction of these managers was not giving the proper support to the ERP implementation process. Despite this initial negative reaction, the problems were gradually solved and, interestingly, reversing the responsibility of the outdated cases: in many cases the cause of the updating delay was in the technical area due to outstanding issues of some supporting processes (e.g.: a change in the tutor of a student wasn't formally communicated to the support section by the former tutor).

In 2006, the updating of the network servers operational system left SIGEPI incompatible to operate under this environment. The continuity of SIGEPI was at risk. Fortunately, a solution was found by the team of analysts but at the cost of rewriting many database programs with the system being partially operated for many months.

Another problem concerns the paper work data collecting. Researchers of the IPEN that are interested in financial support from the funding agencies need to fill in another database named Lattes Curriculum. This curriculum is a government database where the academic researcher and the technological production have to be updated. Besides that, those researchers who are also involved in the IPEN's Post-Graduation program need to supply more detailed information concerning their academic production to the “CAPES Report”. The Lattes Curriculum is an important public personal database, thus besides the financial aspect, the researchers are also interested in keeping this database updated because the access to the data is public and it is also a source of who is doing what. The CAPES Report is used for the IPEN's Post-Graduation external evaluation; therefore it is important to keep the data updated in

order to obtain the highest possible evaluation. A good evaluation means a good mark as well as a high number of scholarships to be granted. The final result of all these bureaucratic demands is that these researchers that are the most productive at the IPEN need to insert their production activities into three different databases. Needless to say that there are lots of complains about the need to supply SIGEPI's databases with their production.

From 2007 to 2009 new efforts to improve at least partially the problems presented above did not work out.

The first one was an attempt to integrate into the SIGEPI most of the information needed by the CAPES Report. The main idea was to outsource the development of the template and the integration with SIGEPI databases. A meeting was held with the participation of one system analyst and the manager of the Systems Development Section, the Research, Development and Teaching director, the teaching management and the Planning and Program Section manager (responsible for SIGEPI) and in that meeting it was decided not to upgrade SIGEPI. The argument that prevailed was that a personal and manual data collecting solution would be preferable to one based on an upgrade of SIGEPI. The main obstacle to change was the difficulty obtaining the data on the deadlines: a personal and manual data collecting approach tends to be more effective than an automated one.

Two additional efforts focused on the integration and use of SIGEPI data integration with the Lattes Curriculum database.

The first effort refers to a technical visit to a Research and Technology Institute, similar to the IPEN, in order to know how they were dealing with Lattes Curriculum database data extracting problem. After knowing that another Research and Technology Institute was developing a solution to extract the data from the Lattes Curriculum database, members of the same team who participated in the decision meeting mentioned earlier visited this Institute for a presentation on their approach. Although their solution proved to work for their purposes, the application of their solution to the IPEN would still demand a lot of reworking efforts in terms of software language programming, manual review of the extracted data as well as some complementary data request for at least one author (the Activity number of the Master Plan where each publication should be connected). Especially due to the need to review a large volume of data, this solution was discarded.

The second effort refers to the possibility of exploring a feature available in Lattes Curriculum database named Institutional Lattes Curriculum. The Lattes Curriculum database has a feature where Brazilian research and teaching organizations may retrieve the production of their professionals and students signed up in the Lattes Platform. Observing the results of a public reference organization in the healthcare sector, the results pointed out a data updating problem. Clearly the results from the two previous years could not be used to point out the institutional results of this organization.

Thus, the final remark is clear: the consolidation of the organizational results cannot depend on the data retrieved and integrated from a database managed by another organization when the data is entered by the researchers on an individual basis and the

publications and other documents which these data refers to are managed by the IPEN's supporting sections. This situation leads to the following situation: the IPEN's researchers will continue to supply such common information into three databases: SIGEPI, Lattes Curriculum and CAPES Report.

#### 4. EXPERIENCE ANALYSIS AND RECOMMENDATIONS

Considering the literature review presented earlier, some factors were selected and their impacts on the IPEN's experience presented in Table 1. Recommendations for future developments are also presented.

Table 1: Factors, impacts and recommendation derived from the IPEN's ERP development experience

<i>Factor</i>	<i>Impacts</i>	<i>Recommendations</i>
<i>Strategic</i>		
Business reengineering / ERP alignment with the organizational mission	Positive: the ERP was developed in the context of a totally new planning process which enable the planning-evaluation process of the macro organizational processes	The introduction of new management processes simultaneously with the development of an ERP may help to consolidate the logic of new planning-evaluation processes
Innovative conceptual design	Positive: the design and implementation of an ERP adjusted to the organizational need  Negative: long design and implementation period of the new system	The ERP design and implementation process should be initiated by testing the functionalities and obtaining the acceptance of the concept inviting the R&D Section most receptive to the new management approaches. Once the concept is proved and accepted then the ERP can be implemented involving the rest of the end users.
Top Management support	Positive: it is crucial for the success of the implementation  Negative: when there is no consensus within the Top Management Team, the integration of the information systems, under the responsibility	Initiate an ERP implementation convincing effort by identifying within the Top Management Team who would sponsor such an effort. The positive results should be used as a benchmark. The difficulties will not be used

	of the managers that do not fully support such an implementation, may be hindered.	against the implementation process
Management of expectations	Negative: when the main expected benefits do not come true, structural aspects of the ERP software may be totally redesigned	It is better having conservative expectations and “unexpected” good accomplishments than having high expectations and disappointing results
Outsourcing	Negative: 1. the challenge of designing the ERP attracted the attention of the internal system analysts staff and created barriers to outsource part of the information system development; 2. specificities of the RTO ERP require high tacit and difficult contractual specifiable knowledge  Positive: when some technical deficiencies that put the ERP current development at risk appeared, consultancy help was accepted	Knowledge organizations of a reasonable size (e.g.: more than 300 members of the workforce) may have many internal processes calling for modernization. Thus the internal system analyst team tends to be limited in terms of member numbers and qualification in order to meet the modernization demands to all supporting processes. These organizations need to define internal rules concerning what ERP modules will be outsourced or not.
<i>Project design and implementation</i>		
Project champion	Positive: a project champion has a systemic view that information systems supporting managers and the design team may not have	The key aspect here is the identification of someone capable of translating the managerial process demands into software operational functionalities to be developed by the system analysts. This professional needs to have good management and technical skills.
Resources dedication	Negative: the system analysts team allocated to the ERP development after the web version had been launched was drastically reduced – many of the following ERP implementations lasted years and are still being	When some of the programming services can be internally developed, the time allocation of the system analysts is always a source of internal dispute. When implementing an ERP, the

	implemented, thus delaying the benefits of perceiving of such an implementation	future time allocation needs to be negotiated in order to assure subsequent additional smaller developments and maintenance activities the ERP will demand
Performance and lack of integration of the preexisting internal information systems	Negative: when the integration of the preexisting system is implemented, users may identify some data errors and may equivocally criticize the new ERP	The managers of preexisting system need to be aware of the fact that users will have an on line data access – thus the importance of the supporting team updating the database as soon as the process changes its status because new data needs to be processed
Lack of integration of the preexisting external information systems	Negative: part of the highly skilled IPEN’s work force need to report their results to other governmental organizations. If the internal and external databases were integrated, common information would be inserted only once and these professionals would be released from these repeated bureaucratic time consuming activities	Whenever possible, the design and implementation of ERP databases should be compatible with external databases. When they are not compatible, end users must be communicated about the technical difficulties in integrating the internal database with the external one.
<i>Behavioral</i>		
Innovation perception as a threat or reworking efforts	Negative: support process managers may resist to the integration of the system under their responsibilities	The reasons for this resistance need to be understood. Such an opposition may result from some process restrictions (e.g. additional training effort or low level workforce) which can be solved by some negotiation efforts.
Concurrence with other information systems being implemented	Negative: support process managers may prioritize another local information system part which is not connected to the ERP, especially if their superiors do not fully support the ERP implementation	The decision about which part of the ERP should be developed or upgraded first ( for instance, end users may demand new functionalities or supporting process owners may request modifications due to compliance changes )

<p>Attitude due to negative previous information systems experiences</p>	<p>Negative: bad previous experiences faced by the internal system analysts cannot be easily forgotten; thus the willingness to reengage in earlier interrupted projects - even if the scope is changed - may be low</p>	<p>should be openly discussed or, at least, communicated in order to avoid unnecessary misunderstandings The key point here is getting unlimited support from the sponsor of the project (a member of the Top Management Team). He should make sure that the project will be implemented and the time allocated and efforts by system analysts will not be wasted</p>
<p>Attitude due to complexities introduced by the system</p>	<p>Negative: final user perception that such an information system implementation represents only a new obligation: risk of incomplete data survey</p>	<p>The benefits for the users must be clearly communicated. Some evaluation and recognizing practices (e.g. an excellence award) may stimulate the data entering process by the users, especially those highly skilled</p>
<p>User training and education</p>	<p>Negative: all users can be fully trained in the new ERP but if the system is not user friendly or if it does not operate appropriately (slow speed or data loss) the system will be criticized and possibly abandoned</p>	<p>The lower the need of training, the higher the chance that the system will be accepted. If a slow answer or system overload happens, the causes must be immediately identified and solved</p>

## 5. CONCLUSIONS AND FINAL REMARKS

The literature reporting the implementation of non commercial ERP software packages is scarce - in R&D organizations it is even more restrict. In order to contribute to spreading this knowledge, the IPEN's experience was reported and analyzed in relation to the three groups of selected factors – 1) strategic, 2) project design and implementation and 3) behavioral - their impacts in the case and recommendation for future similar developments.

Summing up, this experience made it clear that managers interested in the design

and implementation of a ERP in a knowledge organization need to be patient as well as perseverant to pursue their objectives in spite of the difficulties – the implementation success comes in small victories; the perception of the benefits - although low paced by the entire workforce, from the operational level to the top management team – is crucial for such an undertaking and the motivation by challenge and project importance of the design team – even a small one – is decisive for the project success.

Finally, the analysis and recommendations here presented were developed considering only one organization. New studies in other research and technologies institutes need to be carried out in order to confirm or restrict these analysis and recommendations.

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<sup>i</sup>GEN: Teaching Section; GDC: Scientific Documentation Section; GCL: Commercial Section; NITEC: Technological Innovation Section; GPE: Human Resources Section e DAD: Management Directorship.