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The implementation and deployment of an ERP system: An industrial case study

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Abstract

This article concerns the integration and deployment of the ERP project at Alcatel, a telecommunications company. After a short presentation of the main activities managed by the ERP system, we propose a five-stage deployment model (selection of the vendor and software, deployment and integration, stabilisation, progression, evolution), then we outline the main results obtained at Alcatel in a general way, and we describe the risks, the dysfunctions, and the reasons for them. The sources and conditions for the successful deployment of ERP are also presented. We focus more precisely on the integration and deployment of the planning process in an ERP system. Therefore, we will detail the different stages of the integration step (general design, detailed design, prototyping and validation, testing and implementing of the solution, operation starting). A detailed model of the planning process is built and used as a tool to help the firm's key users at the different stages of the planning process. In order to improve the control process of the planning system, we develop a control helping system based on performance indicators, and particularly dedicated to control the MRP activity. The goal of this project is to improve the reactivity of the planning system as well as to enhance that of the supply chain.

Keywords: Enterprise resource planning (ERP) system; Information system (IS); Planning process; Material requirements planning (MRP) activity; Firm processes; Firm performance

1. Introduction

Enterprise resource planning (ERP) has been promoted by the American Production and Inventory Control Society (APICS) since 1980 by extending the Manufacturing Requirements Planning (MRP II) operation system to other systems of the company such as finance, marketing and personnel. Currently, the overall resources of the firm can be integrated through ERP. According to some ERP system suppliers such as SAP, Baan, Oracle, PeopleSoft/J.D. Edwards, etc. more than 12 modules could be implemented through ERP. The most important modules or processes that an ERP

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system supports are: marketing, sales and distribution, enterprise solution, production planning, quality management, assets accounting, materials management, cost control, human resources, project management, financials, and plant maintenance...

Even if the ERP systems experienced an important development in the worldwide use of Information Technology (IT), in the 1990s [3], the success of integration has continued to be a great source of managerial interest and permanent frustration [25]. Since the early to mid-1990s, the ERP software market has been and continues to be one of the fastest growing segments of the IT industry with growth rates averaging from 30 to 40% per year [4]. Some of the ERP research has concentrated on implementation and post-implementation issues [5,6,18,19]. With ERP penetration at 67%, the ERP market is the largest segment of a company's applications budget (34%) and is expected to remain so throughout 2004 [26]. ERP reflects an innovative business strategy, as the adoption of ERP involves business process improvement, best practices implementation, intra-enterprise integration and inter-enterprise coupling. ERP systems are designed to ease the ERP concept by replacing disparate patchworks of legacy systems across business organisations with synchronised suites of enterprise-wide applications. Potential benefits of an ERP system include productivity and quality improvement in key areas, such as product reliability, customer service, and knowledge management. As a result, ERP systems are expected to enhance market value and the firm's performance through efficiency and effectiveness gains [13].

The ERP systems are considered to be powerful and robust tools for a real industrial change. In this sense, their use opens up the question of innovation rather than closing it. The designated qualities of these tools are known to be mainly standardisation and integration. However, a set of arguments lets us believe that the contribution of these tools is not acquired in advance for different reasons: heavy investments in terms of project time, acquisition costs of hardware and software licenses, dysfunctions of different natures at the operational release of the system, fear and rejection by the end user, etc. A perfect illustration of the common situation called ''productivity paradox'' or ''Solow paradox'' where the traditional question of ''Return On Investment'' (ROI) seems to be completely meaningless.

Concerning the contribution provided by IT systems on firm's performance, literature results are more or less conflicting. Some studies [12,17,30] have attempted to find a positive relationship between IT investments and firm's performance. The research findings have yielded no significant results. Other studies [8,10,21] have also observed no or fewer performance effects associated with increasing IT expenditures, a phenomenon that is often referred to as the productivity paradox. To look at this phenomenon, Hitt and Brynjolfsson [12] suggested that firms will pass on financial gains to consumers through decreased prices in a competitive marketplace to the extent that increased spending on IT yields efficiency and effectiveness improvements. Study findings have shed new light on the productivity paradox associated with ERP systems and have suggested that ERP adoption helps the firms to gain a competitive edge over non-adopters.

The current development of ERP systems could be situated a part of the dynamics of the firm's evolution. The success of such tools is not the result of some management method, but on the contrary is due to long-term vision and strategy. In spite of their success, ERP tools are complex and have ''paradoxical qualities'' designed as characteristics for use: standardisation of course but combined with the willingness to stand apart; integration but, at the same time, without necessarily looking to completely globalise and automise the system. Regarding conformity, the ERP system obliges the organisation's actors to respect a logic, which has strict rules, and offers the organisation's actors new possibilities.

In a recent paper, according to Guffond and Leconte [9], the ERP system could be defined as follows:

- The ERP system is a tool assembling and integrating all data and management skills which represent the firm's activity, in a unique database: from finance to human resources, going through the elements of the supply chain that permanently link the production to purchasing and sales.
- The ERP system is a tool conceptually situated between standard and singularity, between open and close, and having two layers. The ''generic layer'' attends to respond to the needs of all or several firms according to referred and experienced solutions known to be better practices and corresponding to standard rules of management. The ''specific layer''

is a multiuser layer and therefore personalised. It has to take into account the particular characteristics of the organisation by means of lengthy study to see how the firm must adapt.
- The ERP system is a tool composed of applicative modules (one per ordinary analytical function of the firm) able to dialog between each other according to a conventional exchange protocol thanks to the unique base and the uniqueness of the processed data. Then each module receives information coming from the other modules and sends its own data to the other modules.
- Lastly, the ERP system is a tool that the managerial literature presents as a tool able to control the firm in real-time, using a transversal perspective; it is then pulled up to a level considered as a change vector, in view of reaching a new era of industrial rationalisation.

In spite of the inherent qualities and advantages of ERP systems, there are some problems we can identify through the different stages of ERP deployment. For example, the type of problems and issues that arise from the implementation of ERP systems range from specific issues and problems that can come up during the installation of an ERP to behavioural, procedural, political and organisational changes, etc... that manifest themselves once the system is installed [1,2,29]. The results of the article by Verville and Halingten [29] prove, contrary to the wide-standing belief that IT acquisitions are done routinely and fairly simply, that acquisitions of this nature (for ERPs) are complex, involved, demanding, and intensive. According to Peterson et al. [20], the ERP systems are complex software; consequently, implementations are difficult, long, and expensive. For these reasons, the business objectives are sometimes not even reached a year after the implementation.

The major business drivers behind ERP implementations are: improving productivity, providing competitive advantage, and satisfying customer demands [27]. Concerning financial performance, Hayes et al. [11] indicate that participants in the market capitals believe that the adoption of an ERP must enhance the future performance of firms; however the range of potential returns remains unknown. Hunton et al. [13] examined the longitudinal impact of ERP adoption on firm performance by matching 63 firms identified by Hayes et al. [11] with peer firms that had not adopted ERP systems, by comparing financial performance indicators. The results indicate that return on assets, return on investment, and asset turnover were significantly better over a 3-year period for adopters, compared to non-adopters. They report significant differences arise because the financial performance of non-adopters decreased over the time while it held steady for adopters. Also, they report a significant relationship between firm size and financial health for ERP adopters with respect to return on assets, return on investment, and return on sales. The results of Hunton et al. [13] are consistent with those of Poston and Grabski [22] who reported no pre- to post-adoption improvement in financial performance for ERP firms. The latter authors examined the effect of ERP systems on firm's performance over a 3-year period. They found a significant decrease in the ratio of employees to revenues in all 3 years, and a reduction in the ratio of cost of sold goods to revenues in year 3. However, they reported no significant improvement in the ratio of selling, general and administrative expenses to revenues, or residual income (net operating income minus imputed interest).

Concerning ERP process deployment, key users and key activities, and success factors, Somers and Nelson [27] presented an article on the taxonomy of players and activities across the life cycle of the ERP project. By combining the factors of implementation with a process perspective, they examined a comprehensive framework that allowed them to investigate the issues that should dominate each implementation stage of an ERP. In the research literature we analysed, we identified a number of factors that affect the implementation process of an ERP and its success [7,14–16,28]. The identified success factors are: support and agreement of the top management, redesign of business processes, investment and user training, lack of customisation, use of business analysts and consultants with technical and business ability, ERP system integration with the other Information Systems (IS) (business), careful selection of software and vendor, standardisation, transition planning and data conversion, open and frank change of business, ongoing business support.

Having examined previous research on ERP systems, in the rest of the paper we will present two main sections and conclude with some perspectives. The first section concerns the deployment of the

ERP project at the firm Alcatel: after a short presentation of the main activities managed by the ERP system, we propose a five-stage deployment model, then we outline the main results obtained at Alcatel in a general way, and finally we describe the risks, the dysfunctions, and the reasons for the latter. The section finishes with a paragraph on sources and conditions for the success of the deployment through the different stages of the project. The second section presents in more detail the deployment of the planning process. First we will develop this process integration model from the design step to the operational starting. Then, we detail the evolution and progression stage in order to control the planning activity in the short term with the help of some process performance indicators. A conclusion and some future works end this paper.

2. The ERP project deployment at the firm Alcatel

In a recent study [23], it was outlined that in big firms, the average cost to implement an ERP system is approximately equal to 1% of the firm's turnover and the average lead time is about 20 months. China Telecom Corporation for example, rolled out the complete SAP solution over 2 years at 20-plus subsidiaries. For the company Alcatel, the country-wide kick off of the ERP project started at January 1998 in parallel at AVTF Alcatel-Annecy and at its subsidiaries. The big-bang solution successfully went live thirteen months later (February 1999) in all locations with a total of 350 end users and remains a significant success for the company to date.

The industrial and business contexts of the firm Alcatel in Annecy cover the following activities: design, manufacturing, sales, distribution, and customer service. The design and manufacturing activities concern vacuum pumps, leakage detectors, and engraving facilities. Alcatel sells its products directly from Annecy and via subsidiaries located in the USA, the UK, Germany, and Holland. The customer service exists via an international network of specialised service centres located in Annecy, Hingham, Phoenix, San Jose, Livingstone, and Seoul...

The IS landscape has been designed to cater the major needs of the company in the following area: finance, logistics, production, project management, and customer service. The ERP system implemented at Alcatel is R3/SAP. Seven main modules (financials, control, sales and distribution, materials management, production planning, business, and customer service) manage and control the following activities:

- The *activities of the finance department* are ensured by the *Financial Accounting* module (FI), which deals with the accounting, and the *Controlling* module (CO), which deals with the inspection of accounts.
- In the *area of logistics,* the tasks of sales and distribution are ensured with the help of the *Sales and Distribution* module (SD), and the inventory management and purchasing tasks are ensured with the help of the *Materials Management* module (MM).
- The *production activities* such as technical data management, material requirements planning, manufacturing control, and planning are ensured by the use of the *Production Planning and Control* module (PP).
- The *project management activities* are carried out by the *Project System* module (PS), which deals with the management of special business.
- The *activities of the customer service domain* such as repairing, operation planning, lending (loaning), and management of serial numbers are ensured by the *Customer Service* module (CS).

Today, approximately 40% of the firm's employees are end users (≈350 employees) and involved with the ERP system.

2.1. Modelling of ERP deployment and integration

Researchers described the implementation process of the ERP system by models having three to six stages [27]. Rajagopal [24] presented a model using the following six stages: *initiation*, *adoption*, *adaptation*, *acceptance*, *reutilisation*, and *infusion*. The strength of this model is situated at the last two stages representing post-adoption behaviour. Verville and Halingten [29] presented a model of the ERP software acquisition process including six distinctive yet interrelated processes: *planning*, *information search*, *selection*, *evaluation*, *choice*, and *negotiations*. The paper depicts the main processes and many of the constituent

activities, issues, dynamics, and complexities that pertain to the acquisition of ERP software.

At Alcatel, the ERP project life cycle was carried out according to a five-stage model: *selection of the vendor and software*, *deployment and integration*, *stabilisation*, *progression*, and *evolution*.

- *Selection of the vendor and software*: before the final selection of the vendor and software, the expression of requirements and specifications was clearly defined, the objectives were fixed, the budget was elaborated, and the contracts were established... Alcatel set a final goal for this project: the new system needed to help the company must increase organisational efficiency, achieve transparency and real-time management, tighten internal control, and enhance collaboration between departments. The lead time for this stage was about 6 months (decision at October 1997).
- *Deployment and integration of the ERP system*. The main steps are the following:
  - *General design*; the different processes of the firm are defined and formalised, and the identification of ERP functions are used. At the same time, some external applications are kept. The identification of specific development and prototyping is done... The lead time was between 3 and 5 months.
  - *Detailed design*, *realisation, and prototype validation*; this step concerns the instantiation of the ERP modules using a detailed approach. The different tasks of this step are: unit testing, specific developing, definition of authorisations for end users, definition of the beginning or procedure starting, writing of user guides, preparation of user training, building of integration test scenarios... The lead time was between the following 4–6 months.
  - *Implementation of the solution*; this step concerns testing and final validation of the prototype. For this purpose, appropriate tests (for modules) and integration tests (for transversal or inter-modules) were designed. The lead time for this step was about 1 month.
  - *Starting preparation*; it was a matter of the real start testing. The lead time was about 1 month.
  - *User training*; it corresponds to a key step of the success of the ERP system integration. The lead time was between 1 and 3 months.
  - *Operational starting with production*; for Alcatel the actual starting was in February 1999 (only 12 months from the 2nd step of deployment and integration).
- *Stabilisation*: during this stage, users understand, assimilate and then appropriate their new tool. The number of phone calls received per day by the key users is one of the performance indicators that offer an objective evaluation. The firm's teams using the ERP system became autonomous after about 2 years of manipulation. During the period from 1999 February to 2000 December, the firm started the project of ERP version change and the project concerning the change of the financial unit (use of the Euro versus the Franc).
- *Progression*: after 2 years of potential use during the progression stage, the key users clearly detected the key processes of improvement. Usually, some of them have been detected since the deployment and integration stage. However, in most cases, the integration of an ERP system is done according to an iso-functionality way (resumption of strictly existing functions without modification) in order not to disturb the starting of the new system and to ensure its functioning, and not to completely disorientate the end users.

  It is just at the stage of progression that the project team started potential modifications with the help of ''Delta Projects'' or ''Enhancement Projects'', when key users tried to bring improvements in their areas (1 year). In 2001, all the subsidiaries of Alcatel were using the ERP system; the replenishment of the different subsidiaries was optimised.
- *Evolution*: during the evolution stage, key users control the tool in their area of skills perfectly, in terms of advantages and disadvantages of the ERP system. They can then propose important evolutions of the IS in order to:
  - Optimise the tool itself by proposing important specifications such as; automatic processing of manufacturing lead times, improving the control of promised components, processing using the demand point method with adapted relations... These specifications allow the decision help system to evolve and the application of the ERP system to be simplified by the use of ergonomic interfaces grouping the necessary information on the same screen.

- Optimise the ERP deployment process itself. Indeed, after 2 years of use, the project teams can focus on the processes to be improved. Usually, during 1 year, the processes and tools quickly change in a significant way.
- Reduce the number of specific programs; the firm's goal is to replace the maximum number of these specific programs by standards proposed by the ERP system itself. Since 2002, the firm Alcatel has prepared the project for the next version of the ERP system in order to increase the possibilities of improvement.

From the evolution stage, we can include the projects of a new version of deployment that, according to the ERP system, could be revealed as hard and heavy projects (strongly bound to the number of specific programs). These projects (version change, change from the Franc to the Euro, hot-package...) are inevitable ways for the firm to develop and to follow the evolution of the market.

2.2. The results of the ERP integration

2.2.1. Contribution of the integration of an ERP to the firm in a general way

Today, with the experience of more than 5 years in ERP use, it is possible for us to outline some of the important contributions the integration of ERP has made to the firm Alcatel and IS in a general way:

- *Integrated IS*: the whole firm's domains and managing areas are managed by the different modules of the ERP system. Then, the firm can cover all its functionalities with the same tool; accounting, controlling, manufacturing, supplying, dispatching, business, purchasing, after sales service, planning, inventories management, quality, and wages... However, it is important to note that the modules related to each of these services can also be implemented separately without altering the efficiency of the ERP system. In fact, the bridges done to link these modules are implemented in an automatic way (an inventory movement corresponds to the accounts, the customer's demands are taken into account directly by the MRP module and the forecasts are used up...).
- *Tight control of physical flows*: at any time, it is possible to have the information in real time concerning the state of stock by discernment of; free use quantities, blocked quantities, quality control quantities, customer demand quantities, customer and suppliant reserved quantities (consignation), purchasing quantities, reserved quantities, transferred quantities between stocks and work centres... Also, for a given component, it is possible to retrace the trajectory movement through stocks for several years in terms of quantities and dates; sales, transfer between stocks, quality control, supplying returns, depreciation...
- *Tough control of information and financial flows*: according to the information traceability, each operation is stored with the operator's name, the date and sometimes the hour of the transaction. For example, this traceability is widely used in stock management, in purchasing demands (dates of: creation, modifications, computing, invoicing...), and for the update of component information data (dates of component modifications since the use of the ERP system).
- *Better security of IS*: according to the management of "profiles and authorisations" which are independently user adapted from the ERP modules by transaction, the IS security is better. Another advantage is the ease and speed of accessing information.

The ERP system unified data and applications with a central, secure, and role-based access to all information system modules. Users have personalised access and single sign-on has resulted in significant time savings and productivity gains because users only have to log on once.

- *A process approach is used*: consequently, most of the functions of different services in the firm are interconnected. For example, when a new flow is implemented as a supplier consignation, an integration test is made between the key users of the different modules of the ERP system: financial, purchasing, stocks management, distribution, manufacturing, planning...
- *Reliable information and data coherence*: using a better following of the supplier demands and information traceability, the information is reliable and data is coherent.
- *Unique and identical information in real time for all users*: the unified data and applications and the uniqueness of the database, whatever the module or the function of the system, allow the same

information to be given to all users at the same time thus allowing processing redundancies to be avoided. For example, the state of stocks of a common component to several production shops, the state of a purchasing demand, and the supply date of a customer's demand...

- *More rigour in data management*: for example, the firm can give more precise data and information concerning the customer's demands...

The return on investment (ROI) of such an integration project of an ERP system is very difficult to calculate. For the firm Alcatel, despite everything, the main profits are evaluated as 30% gain in productivity in the financial domain. The gain in efficiency, the speed at which information circulates, and the flow control are more difficult to evaluate, but they are sure and certain.

2.2.2. Contribution of the integration of an ERP to the different stages of deployment

The main results of the ERP system deployment continually progress with the different stages of integration (Section 1). These results could only be evaluated from the stabilisation stage. They are related to the *stabilisation*, *progression*, and *evolution* stages:

- The results of the *stabilisation* stage could be outlined in three points:
  - The ERP skill group, called ''key users'' group, is autonomous and uses a unique source of information (a unique database),
  - Some ''leaders'' are revealed from users, they can actively participate in the future projects,
  - The objective information comes from the end users to the ''key users'' group.
- The results of the *progression* stage could be presented as follows:
  - The end users control the ERP system,
  - The procedures are applied and the users' guide is regularly updated,
  - The database is completed,
  - End users appropriate the ERP system and efficiently manage and control the processes which depend on their area of skills,
  - Key users define enhancement solutions, but the system is still used as a static database of information. Consequently, the system is not used for the dynamic control of flows. The key users discern the lacks of some performance indicators needed for process control.
- The results of the *evolution* stage are grouped into three categories:
  - The enhancement solutions of the processes are controlled by the users,
  - The functional limits of the system are reached,
  - The key users monitor technological development in order to identify the latest versions or other advanced systems such as; Advanced Planning and Scheduling (APS), Supply Chain Management (SCM), Customer Relationship Management (CRM), etc...

2.3. Risks and dysfunctions of the integration of the ERP system

Most of the risks cover the last three stages of the ERP project deployment: *stabilisation*, *progression*, and *evolution*.

- *Stabilisation* stage risks:

  The key users cannot deal with all the users' demands. Consequently, to respond to their requirements and remain autonomous, some tools and specific programs used before the integration of the ERP system reappear in the firm and some new subsidiary programs are then developed to complement the ERP integrated system, because the later cannot immediately give satisfaction to all users. For example, a specific program is developed with ACCESS to follow the production, another specific program is developed with EXCEL to ensure the design and processing of security stocks, etc... Sometimes, we see the reuse of the initial methods of working. The risk is high when the user is not convinced by the use of the new ERP system, does not yet understand it, or doesn't have enough confidence in the system (for example, verification of the weekly results of the material requirements planning).
- *Progression* stage risks:

  The IS only ensures a reporting function. It is considered such as a static tool (follow-up, detection, traceability—who makes what?) as opposed to a dynamic control tool or a decision making tool.

- *Evolution* stage risks:
  The deployment of numerous and specific programs to make up for functional lacks in the integrated solution. The numerous specific programs are heavy to maintain and thus expensive for the firm, when a new version of the ERP system is integrated.

2.4. Causes of dysfunctions of the ERP system

The origin of these dysfunctions generally comes from the following points:

- In the *stabilisation* stage:
  - The lack of reactivity (the absence of response, or the delay in response) of the skilled pole (key users group), which must respond to a high demand from the internal customers (for maintenance, training, system debugging, unblocking a situation...). Users feel that they are not listened to.
  - The lack of formalisation of some work procedures leads to the overflowing of key users' demands for maintenance.
  - The difficulty for employees to use the new ERP system with rigour. Discouraged by this constraint, it is too easy then to give up and use the old well-controlled tool.
  - At the beginning, the lack of rigour leads to a lack of data reliability.
  - The abolition of the local practices in order to use more homogeneous methods. The ERP system provides management methods with more homogeneity.
  - The process approach applied by the ERP system reveals some problems, which are usually transversal. This kind of problem is due to the organisation of the firm according to a functional approach with relatively separate departments.
- In the *progression* stage:
  - The users' loss of motivation and difficulty to apply the new approach and use the implemented tool.
  - The absence or lack of an operational tool able to control the ERP processes. Relevant performance indicators must be defined and efficient monitoring logistics dashboards built.
- In the *evolution* stage:
  - The absence of an overall strategy and adequate future vision for the evolution of IS.
  - The top management, key users, and the pole of skilled personnel do not have the required will and make the wrong decisions.
  - The project goal and its limits are not properly defined. Very often the objectives are very ambitious and unrealistic.
  - The deployment methodology is very heavy and unstructured.

2.5. Origins and conditions of success of the ERP system

An authentic success of the ERP deployment system requires the actors to be involved with the project and to pass particular attention to the following conditions:

- *The availability of the project teams*: the actors involved in the ERP project (key users, super users...) must be available, skilled, professional, and able to provide clearly needed explanations every time the end users need them.
  - During the implementation and deployment of ERP, the integration stage required a full availability of super and key users, whereas the stabilisation and evolution/enhancement stages required about 80 and 50%, respectively.
  - Once the stabilisation stage is finished and the ERP system is better managed, the number of key users is reduced as was planned in the ERP project at the beginning. Thus, the skills and experiences acquired by eliminated members must be carefully transferred and assigned to the remaining key users according to their field of interest.
  - Throughout the last two stages (progression and evolution), the firm's processes and flows (physical, informational, decisional, and financial) are efficiently improved in several areas (sales, purchases, accounting, planning, etc.). During these stages, the project teams control and capitalise on the skills available. In Fig. 1, we present a promising evolution of the firm's performance and progression in the field of process control throughout the different stages of the ERP deployment.

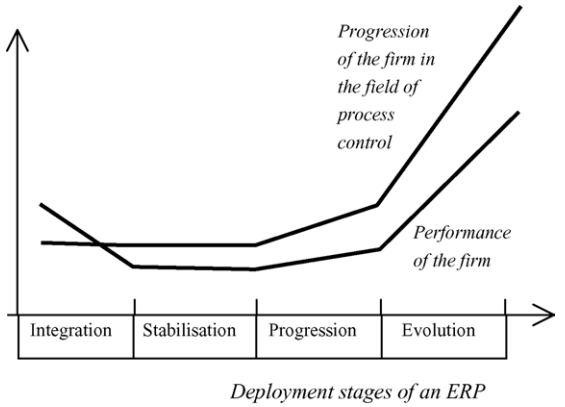

Fig. 1. Progression of process control and performance of the firm according to an ERP deployment.

- *Confidence and knowledge*: the key users must be convinced of the advantages and improvements that the ERP system provides to the firm. Thus, they can efficiently convince future users when training sessions are organised. For this reason, they must be self-confident and experts in their field.
- *Performance indicators*: in order to control the evolution of the firm's processes and the ERP system applications, relevant performance indicators are needed. They are crucial for different reasons such as measure, control, and traceability, in order to prevent deviations, give the system more reliability, and earn the confidence of users. They concern the information analysed throughout the processes of the ERP modules (bills of material, routings, stocks, sales, demands...) as well as the quality of information (anomalies, errors, updates...).
- *End users' training*: the super and key users organise sessions to prepare the end users and employees to use the ERP system. This training must prepare all users to avoid errors and misunderstandings linked to the use of the system and then prevent them from rejecting the tool.
- *Detailed documentation*: the ERP system supplier and project teams provide the users with simple, available, and complete guides and procedures to help them when they encounter a problem.
- *Centralised requests*: the end users' requests and questions are centralised by super and key users according to the organisation of the ERP applications. This approach allows them to:
  - Have an overview of the firm's requests and then focus on the missing elements of the tool according to the user. This approach enables the project teams to decide on future actions according to the importance of the different problems.
  - Filter the information and then avoid redundancy. Thus, if an application or a program exists and can respond or adapt, new programs, applications, or functions are not developed.
  - Compare the users' requests to the existing functions of the ERP system in order to avoid new developments and similar tools.
  - Rank requests, assign them priority, and analyse the feasibility of the solutions.
- *Formalisation of the firm's processes*: the project members collect, analyse, and organise all documents, procedures, indicator supports, production processes, and financial processes, ... in order to formalise the firm's information system. This work of formalisation is crucial as it allows incoherence between the firm's processes and ERP system processes to be avoided.

3. The deployment of the planning process

The production planning process plays an important and crucial role in the optimisation of the ERP system. It is one of the most important processes in the IS and strongly affects the other processes of the ERP system as well as the reactivity of the supply chain.

The firm does not undergo the fierce variation of customer demand. It must be able to anticipate it and then avoid stock-outs when demand accelerates, and overstocks when demand decelerates. The firm must identify how to react on time to the demand change. An ERP system provides new perspectives of progress and evolution for such problems.

The production planning process we present concerns the ''pumping and detection'' activities at Alcatel and its subsidiaries. The ERP applications mainly concerned by the production process are: *Materials Management* (MM), *Production Planning and Control* (PP), *Financials* (FI), *Controlling* (CO), *Sales and Distribution* (SD), *and Project System* (PS).

As we focus on the production planning process in this section, we estime it necessary to present a general design in Fig. 2 and a detailed design in Fig. 3.

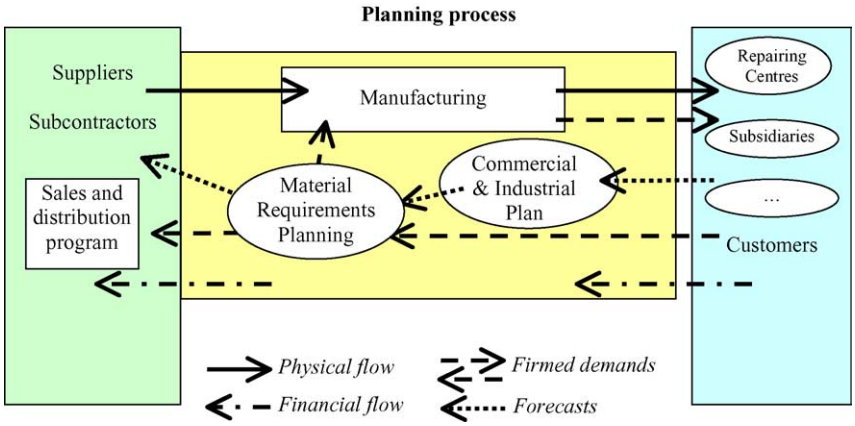

Fig. 2. General design of the planning process.

3.1. Integration of the stages of the ERP project

3.1.1. General design

The different flows and production processes at the firm were analysed and defined according to the ISO 9001 standard, which resulted in the general design of the production planning process presented in Fig. 2.

3.1.2. Detailed design

The production planning process is sub divided into main products, manufacturing lines, and activities. The analysis of production processes is done with rigour and precision. The internal planning process is presented in more detail in Fig. 3. The following step corresponds to the detail of the process according to the activities. Activities are documented with relevant and reliable information.

Let us consider the material requirements planning (MRP) process for example. This process is considered here as an activity that must be controlled (Fig. 4). In this way, we focus on it and identify the following important information:

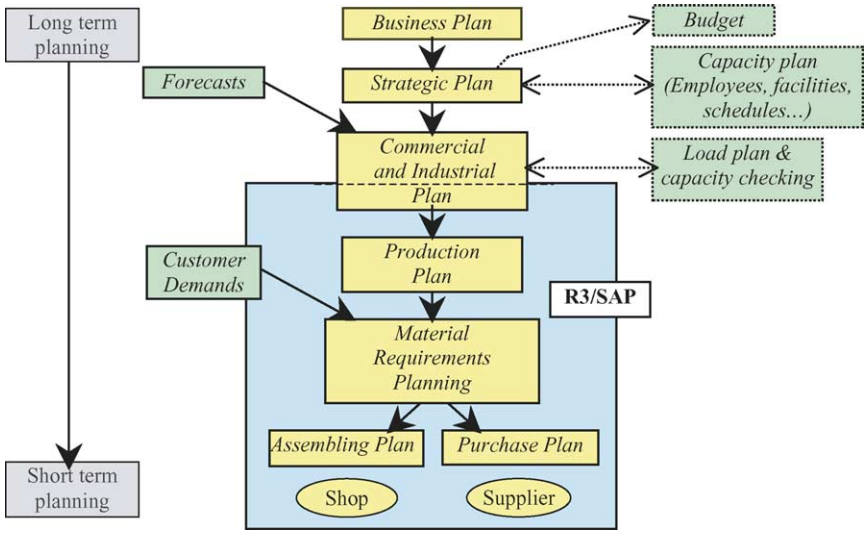

Fig. 3. Detailed design of the planning process.

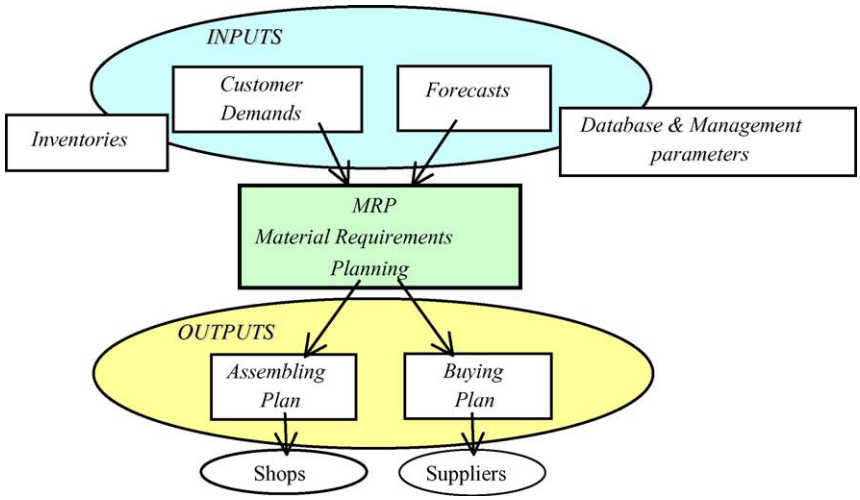

Fig. 4. Inputs to and outputs from the MRP activity.

- The *inputs* to MRP,
- The *outputs* from MRP,
- The *documents* needed to execute MRP,
- The *performance indicators* to control MRP.

The detailed design of the planning process allows us to clearly identify the different activities and performance indicators that control it. For the planning activity in the long term, for example, the analysis of the initial information system allows us to identify:

- The number of product families used in the planning of forecasts.
- The number of components that will be used in the MRP activity.
- The different planning methods that already exist.
- The functioning methods used for replenishment plans...

This analysis of the initial system allows us to highlight the key activities in each process and the results obtained.

3.1.3. Design and validation of the data-integration platform

The system is refined and analysed in order to understand how it functions and then identify the firm's processes. For the forecasts, for example, the planning process key users build a data-integration platform defining:

- A standard industrial planning of product families and the automatic updates of their percentages.
- An overall production plan for crucial components.
- A material requirements planning for the firm.
- An assembling plan for repetitive production organised according to some key production lines.
- The simulation and releasing of production and purchasing orders once MRP is executed.

To ensure maximum ROI, Alcatel required a data-integration platform with exceptional reliability, performance, availability, and scalability to provide the ERP software with more capability. The data-integration platform is able to represent every industrial case at the firm.

3.1.4. Solution implementing and tests

The firm's processes are elaborated and tested using the built data-integration platform. First, the tests are executed separately module by module and then together into all modules in order to identify the impacts on the different modules.

For the production planning process, the integration tests concerned the following modules: *Production Planning and Control* (PP), *Sales and Distribution*

(SD), *Materials Management* (MM), *Controlling* (CO), and *Financials* (FI).

In order to have a better understanding of what the integration tests to be validated are, the model used in the planning process is based on Figs. 1–5. It is applied as a help tool for prototyping, testing, and outlining:

- The different activities of the planning process,
- The relationships between the planning process and the other processes of the IS.

This model is also an appreciable help tool during the implementation stage. The adaptation of the worldwide firm solution to the ERP system is validated since the tests are run correctly with the data-integration platform.

3.1.5. Checking of the database

Information and data are gathered, organised, checked, and then transferred to the ERP database and modules according to the planning process model (Fig. 5).

3.1.6. Preparation of the operational starting

The operational starting is first emulated with a test machine. The last alterations and anomalies are detected and anticipated in order to avoid them in the real-time non-emulated starting.

3.1.7. User training

Once the designed tests are executed, end users are trained to learn the firm's flows and processes from key users. The training is organised according to the ERP applications and firm's services. The act of training is one of the most important because it is crucial for the success of the integration of the ERP system. The main users are closely involved in the planning process as are the organisers, planners, and purchasers.

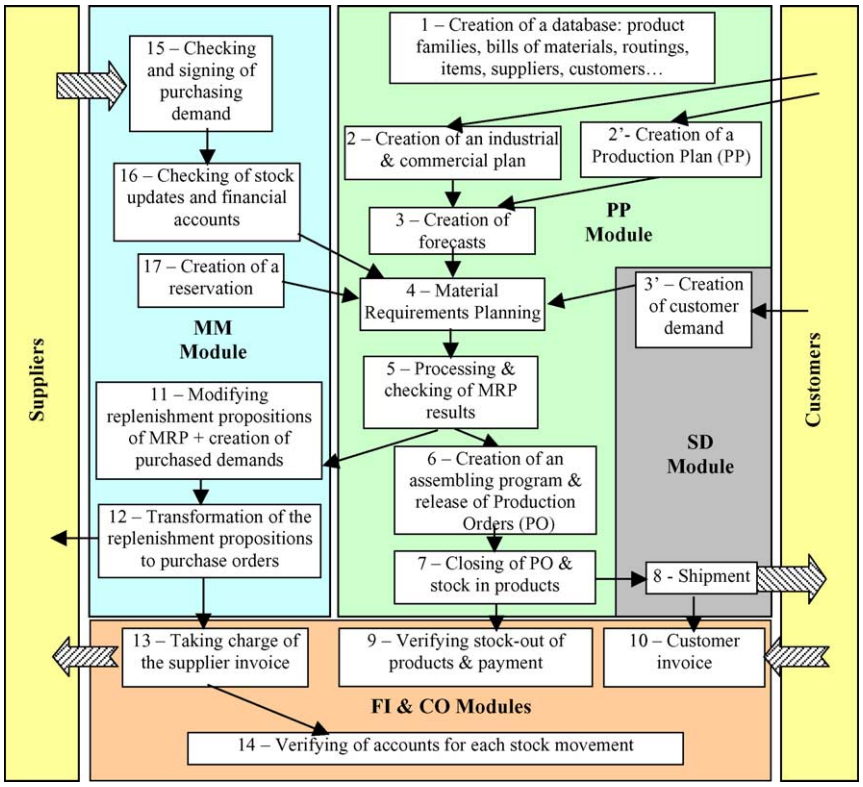

Fig. 5. Detailed modelling of the planning process for the integration tests.

3.1.8. Operational starting

The operational starting is an exact view of the last simulation. Consequently, this must now just be a simple formality for the project team members and users.

3.2. Progression and evolution: short-term planning activity control

What are the chances of the project optimising the production planning process and more precisely the MRP activity? It is certain that the optimisation of the planning process enables the firm to make gains and enhance its reactivity relative to the workforce, customers, and suppliers.

- Regarding the *firm's workforce*: the users must keep information reliable and data accurate, and improve the management methods to adapt them to the planning activity. In this way, it is important to:
  - Make the management processes simpler and keep them more consistent by using and controlling the applications of the ERP tool.
  - Refine, formalise and control the management rules executed in the ERP tool.
  - Identify a simulation process for the reactivity of the management system.
- Regarding the *customers*, the firm must be more outstanding and reactive on the market to keep short, stable, and consistent delays with the customers and thus respond to their demands on time.
- Regarding the *suppliers*, the firm has to be credible to their subcontractors and suppliers, so consistent forecasts provide them with more reactivity. If the market is credible, it is thus more outstanding and more flexible.

As the permanent improvement of reactivity is one of the firm's main goals, the central action consists in driving the control system of the short term planning process activity. To reach this goal, the firm should control the MRP activity, which is a significant one in the planning process. In this way, some performance indicators were defined to control MRP throughout its inputs and outputs.

3.2.1. Performance indicators controlling the MRP inputs

Concerning the MRP activity *inputs*, as shown in Fig. 2, the MRP process needs three kinds of data in order to find out what the material requirements and dates of release are: database information (33,000 components, 13,000 bills of materials and routings...), stock levels, and gross requirements (forecasts, customer demands and reservations...). So, to control the inputs of the MRP activity, we defined some performance indicators in different areas.

- To improve the *consistency of the database*, we implemented three process indicators:
  - *Number of anomalies* by component and by production line (Fig. 6).

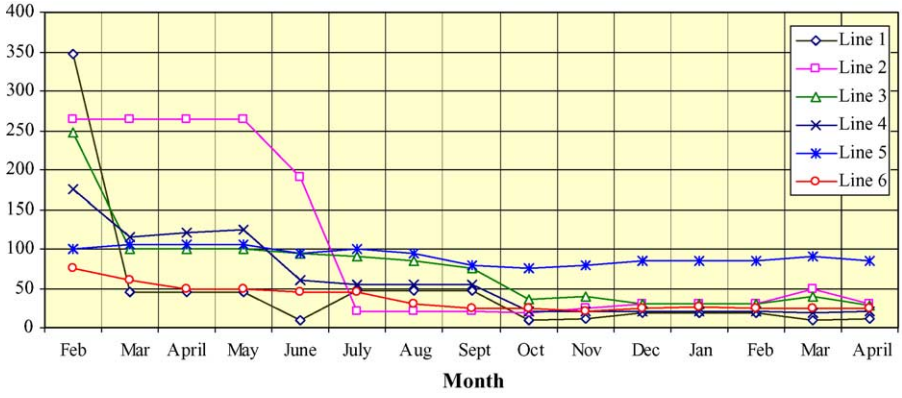

Fig. 6. Evolution of the number of components with important anomalies per production line.

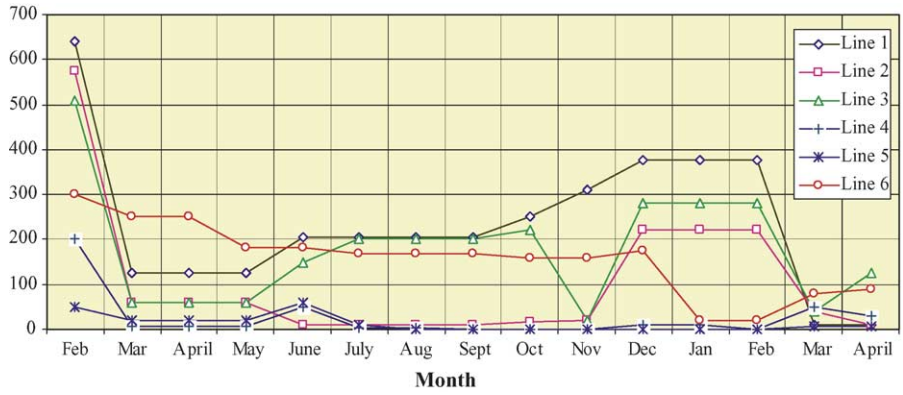

Fig. 7. Evolution of the number of anomalies in bills of materials per production line.

- *Number of bills of materials anomalies* by production line (Fig. 7).
- *Component creation process indicator* in order to accelerate the process of creation.

- To refine and control the *management rules and parameters* (replenishment profiles, security stocks, and security delays), the following indicators were implemented:
  - *Number of stock-outs* per week. The ERP system allows the integration of forecasts, firm's requirements, assembling plans, production orders, and replenishment program data into the planning process. This integration enables us to use an indicator directly issued from the MRP activity. This indicator corresponds to the stock replenishment in terms of the number of days.
  - *Evolution of the purchased components stock* per production line.
  - *% of the purchased orders cancelled* by the buyer as opposed to the purchase demands proposed by the system per week and per production line.
- To control *the anomalies* when requirements are expressed (customer demands, reservations, independent requirements...), we implemented the indicator corresponding to *the number of input elements* used in the MRP activity (Fig. 8).

3.2.2. *Performance indicators controlling the MRP outputs*

Concerning the MRP activity *outputs*, once the MRP activity is executed, the improvement actions

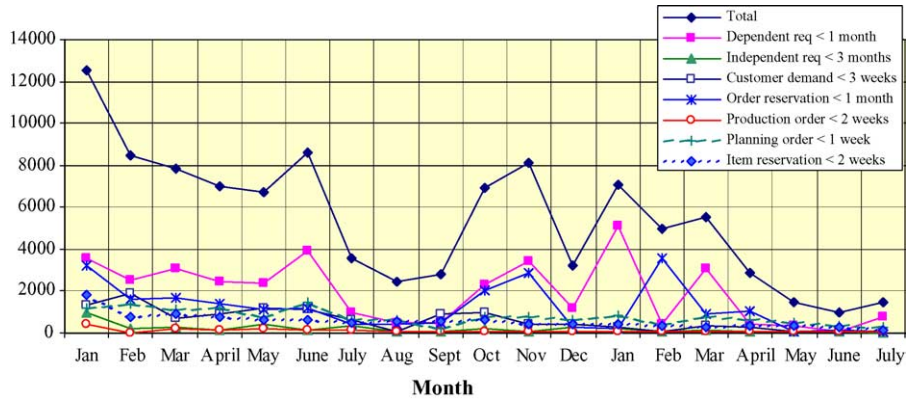

Fig. 8. Example of anomalies expressed into the MRP process.

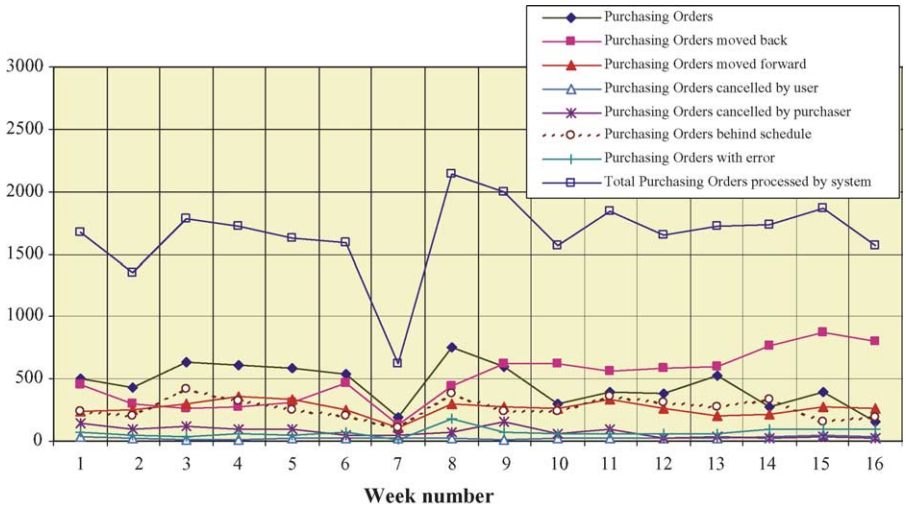

Fig. 9. Evolution of exception messages issued from the MRP process.

depend on the evolution of the *number of exception messages* concerning the Sales and Distribution module (SD) (Fig. 9):

- *Number of purchasing orders*.
- *Number of purchasing orders cancelled by the purchaser* and the reasons for these cancellations.
- *Number of purchasing orders* that the system proposes to move forward.
- *Number of purchasing orders* that the system proposes to move back.
- *Number of purchasing orders cancelled* by a user or a purchaser.
- *Number of overstocks* (unlimited stock replenishment or slow rotation) (Fig. 10).
- *Number of stock-outs* (negative stock replenishment) (Fig. 10).

Some of the actions allowing the improvement of these performance indicators correspond to the evolution of management parameters (for example, consider a variable batch size with relation to the process and component needed).

In the following table, we summarise the performance indicators used at Alcatel today to control the MRP activity throughout its inputs and outputs.

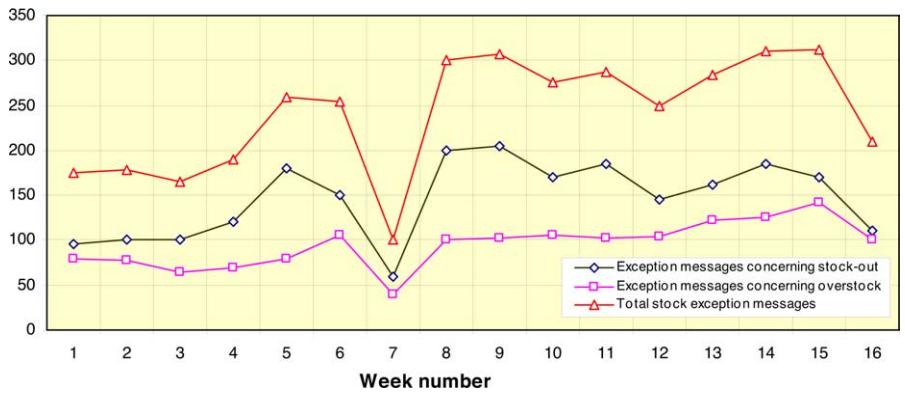

Fig. 10. Evolution of exception messages concerning stocks and issued from the MRP process.

MRP input indicators
Number of component anomalies/production line
Number of bill of material anomalies/production line
Evaluation of the component creation process
Evaluation of the input elements of the MRP activity

MRP output indicators
Number of purchased orders released by MRP activity
Number of purchased orders cancelled by buyers/number of total purchased orders released by the system
Number of purchased promises that the system proposes to move back, move forward, and cancel
Number of overstocks according to ABC component classification (infinite coverage of stocks)
Number of stock outs according to ABC component classification (negative coverage of stocks)
Evolution of the purchasing components stock/production line

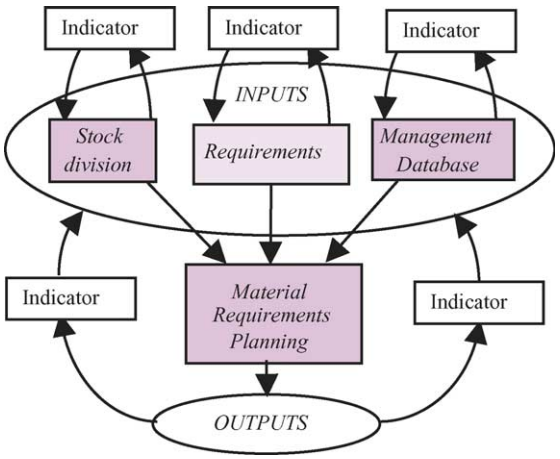

Fig. 11. Control of the MRP activity.

These indicators help the users to take faster and tougher decisions and apply the right actions on the system itself and on the management methods concerning stock replenishments, purchase orders, production orders, and component profiles... The control system enables us to control our management system better (Fig. 11).

4. Conclusion and perspectives

The study presented in this article focuses on the implementation and deployment of the ERP system at Alcatel in Annecy, France. Following the investigation of previous research on the ERP system and its integration into firms, we developed two main sections. The first one develops the ERP system deployment using a five-stage model: selection of the vendor and software, deployment and integration, stabilisation, progression, and evolution. The second mainly concentrates on the integration of the production planning process throughout the following steps: general design, detailed design, prototyping and validation, testing and implementing, and starting. To control the MRP activity of the production planning system and thus improve the firm's reactivity, some performance indicators were developed and plotted.

Even if it is not very easy to measure the return on investment (ROI) of such a project, the implementation and deployment of R3/SAP are considered a huge success and a major advance for the company in the area of information management. We can confirm that this project provides the firm with a lot of advantages such as:

- Unified data and applications with a central, secure and role-based access to all information system modules,
- A process approach with an adaptation of the system to the evolution of the firm's organisation,
- Tight control of physical, informational, decisional, and financial processes,
- Coherence and reliability of data,
- Uniqueness and availability of information at the same time for all the firm's users,
- Visibility of information due to flawless data integration between the different functions and data sources,
- Ease and speed of accessing information,
- Comprehensive business analysis,
- Rigour in management,
- Single, consolidated, and timely vision of their business.

The success of the integration of ERP is due to consistent and tough support from top management, excellent project planning, and teamwork. Alcatel took advantage of the flexibility and scalability of R3/SAP in order to make tough decisions and focus on essential needs while maintaining full adaptability to develop the system and respond to changing requirements. It helps actors to make faster decisions and get

tighter on management control. The company took a huge leap forward to gain business insight, achieve organisational efficiency, and increase productivity. With R3/SAP software, Alcatel is equipped with one common solution that provides the flexibility to respond to changing and growing business needs. This flexible and adaptable solution plays a critical role in enabling the company to achieve maximum business agility and further enhance its competitiveness. Under the new environment of the IS, the major important functions of the company are fully integrated. This integration accelerates the flow of information and encourages internal collaboration. In addition, this integration of data between the different functions allows easy analysis of performance indicators, which in the past used to be an extremely time-consuming process.

As planned, Alcatel will continue to extend the use of R3/SAP to its other subsidiaries. Today, it is preparing the integration of a new version of the IS. In parallel, it will make enhancements and introduce further developments to further maximize the benefits. To give an overview of the firm's functions, as well as internal and external processes, the company monitors technological development and plans to extend the use of ERP to other advanced systems such as; Advanced Planning and Scheduling (APS), Supply Chain Management (SCM), and Customer Relationship Management (CRM), which will allow it to take care of its supply chain and to manage customer relationships better.

This ultimate goal will allow the firm to have a complete overview of all its internal and external processes with users, partners, suppliers, and customers, on one single platform. Alcatel has achieved an important first step towards that goal by linking together its different processes in the ERP system. The next challenge is to integrate disparate data from heterogeneous sources and to apply a control system integrating consistent performance indicators to the ERP process. When the project is complete, Alcatel will have a control cockpit with key performance indicators across all internal and external processes, further improving its business efficiency and competitiveness.

References

[1] E.L. Appleton, How to survive ERP, Datamation 43 (3) (1997) 50–53.

[2] P. Benson, F. Rowe, ERP project dynamics and enacted dialogue: perceived understanding, perceived leeway, and the nature of task-related conflicts. Database for Advances in Information Systems, Fall (2001) 47–66.

[3] T.H. Davenport, Putting the enterprise into the enterprise system, Harvard Business Review 76 (4) (1998) 121–131.

[4] Eckhouse J. ERP vendors plot a comeback. Information Week, 718, 1999; 25(1):126–8.

[5] J. Esteves, J. Pastor, Enterprise resource planning systems research: an annotated bibliography, Communication of AIS 7 (8) (2001) 1–52.

[6] J. Esteves, J. Pastor, J. Casanovas, Measuring sustained management support in ERP implementation projects: a GQM approach, in: Proceedings of the Eighth Americas Conference on Information Systems, 2002, pp. 1381–1389.

[7] B. Fitsgerald, T. O'Kane, A longitudinal study of software process improvement, IEEE Software (1999) 37–45.

[8] V. Grover, J. Teng, A.H. Segars, K. Fielder, The influence of information technology diffusion and business process change on perceived productivity: the IS executive's perspective, Information Management 34 (3) (1998) 141–159.

[9] J.L. Guffond, G. Leconte, Les ERP, puissants outils d'organisation du changement industriel. Revue Sciences de la Société, Special issue on ERP 2 (2004) 61.

[10] D.H. Harris, Organisational linkages: understanding the productivity paradox, National Academy Press, Washington (DC), 1994.

[11] D.C. Hayes, J.E. Hunton, J.L. Reck, Market reaction to ERP implementation announcements, Journal of Information Systems 15 (1) (2001) 3–18.

[12] L.M. Hitt, E. Brynjolfsson, Productivity, business profitability, and consumer surplus: three different measures of information technology value, MIS Q 20 (2) (1996) 121–142.

[13] J.E. Hunton, B. Lippincott, J.L. Reck, Enterprise resource planning systems: comparing firm performance of adopters and nonadopters, International Journal of Accounting Information Systems 4 (3) (2003) 165–184.

[14] T.H. Kwon, R.W. Smud, Unifying the fragmented models of information systems implementation, in: R.J. Boland, Jr., RA. Hirschheim (Eds.), Critical Issues in Information Systems Research, Wiley, Chichester, 1987, pp. 227–251.

[15] H.C. Lucas Jr., Information Technology for Management, 7th ed., Irwin/McGraw-Hill, Boston, 2000.

[16] K. Lyytinen, L. Mathiassen, J. Ropponen, Attention shaping and software risk—a categorical analysis of four classical risk management approaches, Information Systems Research 9 (3) (1998) 233–255.

[17] M.A. Mahmood, G.J. Mann, Measuring the organisational impact of information technology investment: an exploratory study, Journal of Management Information Systems 10 (1) (1993) 97–122.

[18] D.G. Na, W. Jang, D.W. Kim, Development of a resource planning system for compound semiconductor wafer manufacturing, Journal of Materials Processing Technology 138 (1-3) (2003) 372–378.

[19] F. Nah, J. Lau, J. Kuang, Critical factors for successful implementation of enterprise systems, Business Process Management Journal 7 (3) (2001) 285–296.
[20] W.J. Peterson, L. Gelman, D.P. Cooke, ERP Trends, in: Conference Board, New York, NY, 2001.
[21] A. Pinsonneault, Information technology and the nature of managerial work: from productivity paradox to the Icarus Paradox, MIS Q 22 (3) (1998) 287–311.
[22] R. Poston, S. Grabski, Financial impacts of enterprise resource planning implementation, International Journal of Accounting Information Systems 2 (2) (2001) 71–94.
[23] PPRA. Utilisation et amélioration des ERP dans le milieu industriel, résultats de l'enquête optimisation des ERP en Rhône-Alpes. Pôle Productique Rhône-Alpes, 2003; p. 09.
[24] P. Rajagopal, An innovation-diffusion view of implementation of enterprise resource planning systems and development of a research model, Information and Management 40 (2002) 87–114.
[25] D. Robey, D.L. Farrow, User involvement in information systems development: a conflict model and empirical test, Management Science 28 (1982) 73–85.
[26] F. Scott, J. Shepherd, The steady stream of ERP investments. AMR Research, accessed at http://www.amrresearch.com/Content, 26 Monday, 2002.
[27] T.M. Somers, K.G. Nelson, A taxonomy of players and activities across the ERP project life cycle, Information and Management 41 (3) (2004) 257–278.
[28] Sumner M. Critical success factors in enterprise wide information management systems, In: Haseman, WD, Nasareth, DL (Eds.), Proceedings of the fifth Americas Conference on Information Systems, Milwaukee, WI 1999; p. 232–4.
[29] J. Verville, A. Halingten, A six-stage model of the buying process for ERP software, Industrial Marketing Management 32 (7) (2003) 585–594.
[30] P. Weill, The relationship between investment in information technology and firm performance: a study of the valve manufacturing sector, Information Systems Research 3 (4) (1992) 307–333.

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