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FROM THE EOQ TO THE e-ERP. IMPACT ON THE ORGANISATION

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Abstract: In the Industrial Engineering there has been an evolution of methods, techniques and tools used to support production management through the 20th century, this paper tries to illustrate. Changes began from the classical method for stock management, well suited for goods with independent demand. Nowadays several concepts have allowed the information integration, methods and procedures in a single system known as ERP. ERPs can cover all the functions in industries on the way to reach the goals fixed by strategic planning. Obviously all these changes have notably shaped the current business structures, and helped to improve the daily management. *Copyright © 2002 IFAC*

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1. INTRODUCTION

During these last years, requirements about renewed Information Systems, and specially management software, have been increased in enterprises. This renovation has been in part promoted by the well-known *Y2K Problem*, the achievement of recognized quality certification and the good behavior of global economy. Given these circumstances, many business have chosen to install an ERP (Enterprise Resource Planning) system to manage (in the sense of master schedule and control) the resources belonging to the whole enterprise.

2. A HISTORICAL REVIEW

Classical methods for inventory management are based on the Economic Order Quantity (EOQ) that considers several factors, like order, shipping and carrying costs, which must be globally minimized. Those methods, ranging from the first deterministic model, known as the Harris-Wilson expression or EOQ (1913) to more sophisticated statistical methods under random circumstances, can be used for independent demand of goods, i.e. products have no relationship with demand of other products.

But let us think on an assembly car factory: it consists in a multiple-stage production system where assembling a large number of quite interrelated components, which form elements progressively more complex, until the final product is obtained. Within this context, the demand of parts (components, elements, etc.) highly depends on the number and kinds of cars to be made, and also this is related to market demand.

This situation can be observed in other industries different from car assembly. In many multistage systems, a huge amount of data has to be managed. Furthermore, relationships between different components of a single product add complexity to information dealing. Instead of having an optimal inventory policy, the objective for those systems is

to guarantee material availability in the right amount, the right place and right time.

Before the sixties, there was not a satisfactory way, from a practitioner point of view, to reach the objective of suitable availability of materials. This implied large security inventory, and consequently high inventory costs, but not completely avoiding the risk of stock break due to lack of components.

Nevertheless, in the fifties, a remarkable conceptual advance, the Gozinto graph proposed by Andrew Vazsonyi (1958) appeared. Gozinto method allows to represent the product structure using a compact network, with all information required to be manufactured: the bill of materials (BOM) and their own relationships. Vazsonyi also proposed a method based on matrix algebra to determine a material availability plan starting form a Master Production Schedule (MPS): i.e. which material, in which amount and when it should reach the production line to obtain the forecasted product quantities on time.

In the sixties the growing number of computers in industry business smoothes the way to MRP systems (Material Requirement Planning), targeted on automatic scheduling of material requirements. This simple technique, developed from methods in use during those years, allows a company to obtain a Material Scheduling (MS) from a Master Production Schedule (MPS).

In 1975 McGraw-Hill publishes a book *Materials Requirements Planning*, written by Joseph Orlicky (Orlicky 1975), settling the bases of the original MRP. During the following years, the popularity increases, not only for the fast reported success by several users, but also for marketing developed by APICS (*American Production and Inventory Control Society*), and some well-known professionals like Goddard, Plossl, Wight and Orlicky himself. (Fogarty and Hoffman, 1983; Mcleavey and Narasimhan 1985)

Once the original MRP was applied, some handicaps arose. First, Master Production Schedule was only considered as an input data. Nevertheless, MPS was usually designed from previous intuitive decisions and, thus, its feasibility was not guaranteed. This aspect lead to incorporate into the system a module for designing Production Master Schedules. On the other hand, the original MRP did not consider capacity constraints, nor the problems finally found on day-to-day factory production. Then, those systems began to incorporate scheduling techniques considering capacity at different production levels and stages.

After 15 years of MRP experience, tools focused on planning capacity and workshop management were added to those systems (the embryonic idea was already mentioned in Orlicky's book).

Closed-loop (CL) MRP systems were released allowing the user to detect feasibility for a given Production Schedule and offering some recommendations to reach a feasible schedule, using an iterative procedure.

CL-MRP system became a great advance for enterprise integrated management, usually including Production, Inventory management and Purchase information, but yet several important areas remained out of the computer-aided management system.

After successive developments, other important areas as Finance, Accounting and Marketing were also integrated. Finally, the connection to group all of them was drawn: the Strategic Planning.

After the CL-MRP, the new systems are focused on the manufacturing resource planning. In 1979, the MRP II (*Manufacturing Resource Planning*) appeared, proposed by Oliver W. Wight, trying to integrate everything in a single system with a single database (Wight, 1994; Wight, 1995).

The original objective of MRP II was to schedule and control the resources involved in the manufacturing process, sales, finance and engineering. Another important added idea to previous releases is the use of simulation for the production systems. In short, the added characteristics by MRP II over MRP are basically:

- Capacity planning (and, in part, also capacity control).
- Defined planning and scheduling levels.
- Structured and documented MPS strategy, considering finance elements.
- Simulation power.
- Closed loop feedback.

At the same time, enterprises already counted on different software packages related to other important management functions in business. Packages for accounting, more or less sophisticated software for cost analysis, support tools for R+D management, computing tools to control import and export materials, and other topics were also available (Petroff, 1993).

The idea of integrated information, methods, procedures and, generally, knowledge in a single system to cover all enterprise functions ends up in the ERP (*Enterprise Resource Planning*) systems. This was not a new idea, but it was hard to put in practice: an ERP system is in charge of planning all the enterprise resources to drive the business towards what the strategic plans point out.

The Ideology or philosophy laying behind a physic system assisted by an ERP is quite coherent and is based on the importance of running and controlling together the finance and the logistic systems.

The objective is to give the same prominent role to run and control the finance flow (ways to get resources, investment, cash flow, money changes and bank accounts) and the management of the logistic systems, in a broad sense. Thus, it takes care of managing material flow from suppliers to clients, including purchasing, manufacturing and assembling (if required), distribution of finished product and sales.

Supply chain is another important concept to establish balances between efforts done and profit obtained from the resource contribution at each production stage.

3. PROVISIONS AND ENVIRONMENT OF ERP SYSTEMS: HARDWARE AND SOFTWARE

Under the perspective of software vendors, the great majority of ERP systems are the result of integrating additional applications to beforehand production management packages mostly MRP-II. That is the reason that leads to refer to a natural evolution from MRP-II to ERP (Norris et al. 2000).

ERP software can be defined as a software application for the enterprise management designed to fulfil any requirement found around those functions of the enterprise. The set of applications is designed to help decision-making and tries to cover each functional area in the enterprise. Moreover, the system must allow users to access in real-time to enterprise information and knowledge and also help the user communication through a transparent workflow. Transparency has the objective of spreading company know-how and avoiding wasting time on monotonous and already solved tasks.

An ERP system is usually built from a number of facilities called modules (see Figure 1), which can be classified as follows:

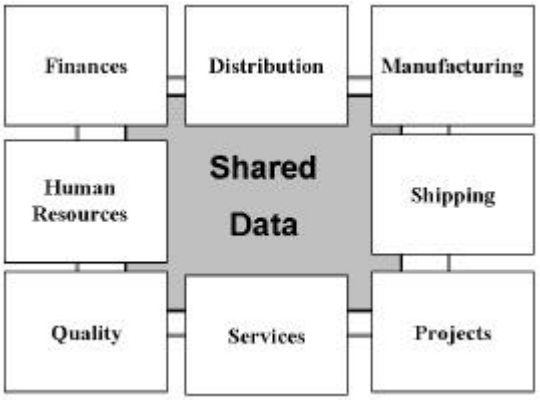

Figure 1: More significant modules for an ERP system. The shared database is remarkable to eliminate redundant data and bugs.

- Basic modules: those ones are compulsory acquired when the client buys this software. They vary according to the manufacturer, but are the most commonly used, are quite standardized, do not need many additional changes and are easily installed (e.g. the accounting module).

- Optional modules: those modules are bought additionally with the above ones, but they still show a high degree of standardization, require a few modifications and no serious problems arise when they are implemented.

- Vertical modules: These are specific modules for each client. Even though there may exist a prototype for them, work is required to adapt them for client particular needs: they must satisfy very varied tasks depending on the client and the applied sector (hospitals, hostels, manufacturing, public administrations, etc.)

Most ERP systems on sale require a client/server environment. The use of this technology allows a staged implantation and development, while offering a configuration with high provision and a suitable database management; in short, it leads to an open system. This open architecture allows companies to select the hardware and operative systems, making easier the adaptation to new technologic advances.

The client/sever technology helps in a great dealt to share a single database, too. Among the most currently used databases, we can find Oracle, Informix, Microsoft SQL Server and DB2. Some ERP manufacturers also facilitate their own database system (like SAP DB for SAP). Anyway, the most important aspect on database, from an ERP point of view, is their open architecture and usefulness for the greatest number of modules.

4. THE ERP MANUFACTURERS

There is a wide offer of ERP solutions. ERP manufacturers usually correspond to broad multinationals with good prestige, among them we may quote: Baan, JBA, J.D. Edwards, Mapics, Movex, Oracle, PeopleSoft, QAD, Ross Systems, SAP and SSA.

In any circumstance, the offered software is high functional level and easily adaptable. Its implantation, though, is a long project extended for a period from six months to one year. and usually with participation of specialized consultancy with wages between 125.000 € and 400.000 €., but we also have notice of reaching two years and higher costs.

On the other hand, small enterprises lean towards closed vertical software integrating functions as accounting, sales, inventory management and wages, etc, mostly due their lack of budget. They do not depend on big companies, because solutions can be found in the national market. In Spain the enterprises may be A3 Software, Dimoni Software, Extra Software, Golden Soft, Isla Soft, Logic Control, Proa and Software de España. The functionality of these packages is limited but enough, and their costs range from 80 € to 3.000 €. In many circumstances, the user buys the package and installs it by him.

Medium sized companies face a more difficult market of solutions. It is quite common they need a great number of applications, some of them are usually home made through their existence. Neither the biggest nor the smallest software manufacturers fit their requirements; but lately, once this potential group of clients has increased, big companies like SAP, with SAPexpress PYMES, and BaaN, with pre-configured releases of BaaN IV, have tried to cover this field. These alternatives demand a shorter implantation time (less than 3 months) and need a smaller funding requirement. Other national ERP manufacturers are trying to compete for this market, like CCS, Logic Control, AS Software, InteWin Software or On-Line, in Spain, without any homogeneity on prices or implantation times.

5. SAP DOMINANCE

Nowadays, the predominant software on ERP applications in Europe is that one offered by SAP (Systems Applications and Products in Data Processing) (see figure 2 for the spanish market).

What now is known as SAP, one of the greatest independent software companies in the world, was founded in 1972 by a group of young engineers in

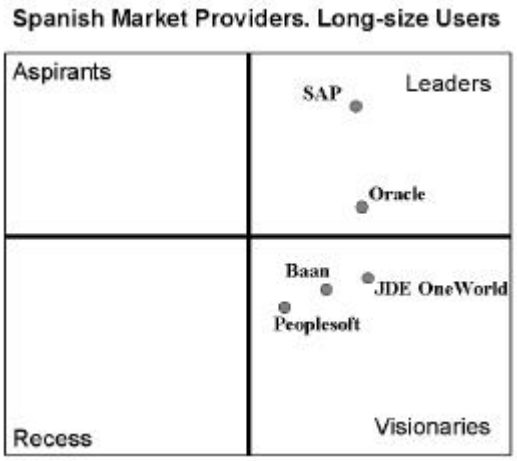

Figure 2: Map of ERP suppliers in Spain (1999). Big ERP manufacturers for long-sized users is shown.

Mannheim (Germany). All of them were former employees from IBM, sharing an integration view about business software solutions for the manufacturing and marketing functions.

A German branch company from ICI (a chemical industry) was the first client, followed by several local companies. During those years, founders reinvested a great deal of the incoming money for further product development and company spreading.

Some years later, in 1976, the company was reconverted into a GmbH corporation, a public limited company. In 1988, the firm was formally constituted as SAP AG and made their initial public offering (IPO).

SAP AG, leader in applications for business under client/server structure, showed in the latest economic results a 38% growth of gross selling, reaching 1860 million € (2.39 billion US dollars). The evolution of company products during the nineties can be qualified as spectacular.

The SAP system is offered by means of two versions, depending on the platform to be implemented: SAP R/2 for Mainframes and SAP R/3 for Client/Server. Our study will be focused on SAP R/3 package.

SAP R/3 is a computer system to manage all functional areas in the enterprise. It has been organized using a group of software modules in three levels, plus an added Workflow module for optimization and reengineering of business processes. The SAP system is based, as the rest of ERP packages, on combining all the business activities and technical procedures in a simple, integrated, robust, reliable and real-time software solution.

6. THE FUTURE: ERP PORTALS?

Everyone has already experimented the advantages of the called horizontal web portals (Yahoo!, Excite, Altavista, Lycos, etc.). They are the most extended ones, and are useful to search over the net, giving services to a heterogeneous set of clients.

Vertical portals, or specialized portals, where ERP systems may find their natural evolution, are beginning to flourish.

Big vertical companies like petrol, chemistry, automotive, aerospace, and even banks, are now being managed by ERP solutions. Corporate portals seem to be inevitable, because they offer specific information related to each industry, plus news, market analysis and other services to clients, which could be handled on-line. At the same time, it can act as a platform for inner application for the own company.

The remaining key idea is that the enterprise and his clients can get applications and information on-line, thought for each different industry and sector, with an easy integration between them contributing to speed up transactions. The manufacturers should give the same level of service and integration to all clients in the vertical market.

Entrepreneur opportunities in vertical portals become interesting due to their ability to organize a group of specific tasks, services and information which users of a certain work require daily and monotonously. The problem arises if these new portals do not get enough specific information and usefulness, because then they will have to face horizontal portals, which are competed developed.

The ERP manufacturers will have to show their ability to serve a vertical market and a virtual market. One of the main problems to be solved will be how their capabilities and systems will fight against more than 500 vertical markets, many of them coming from the on-line versions of their respective industries.

As it was predictable, most ERP manufacturers are introducing themselves in the portal designing: firstly PeopleSoft, then BaaN, SAP, J.D. Edwards and Oracle; in Spain Meta4 has created a new company for the net. Nevertheless, far away from science fiction, in a short time, ERP clients will be able to implement an ERP portal in their companies on-line.

7. ORGANIZATIONAL MODELS EVOLUTION

The organizational evolution has been partially related to the evolution of tools and procedures from those systems. There exists a bi-directional interaction between how a company organizes its direction and which tool is using to support it.

Nowadays, where a high degree of information integration is possible, structural units are broader than their equivalents from the eighties and early nineties. Looking at the current structure of a multinational company (see figure 3), we can see only three main areas: General affairs, manufacturing planning and manufacturing operations.

In a second level we can find several areas from each group. We find inside General Affairs a Human Resources director, a Control Planning director and a Project Management director, inside manufacturing planning, an Engineering and production control director, while in manufacturing operations we can find an different directors for each plant (see figure 3).

This simplified structure highly contrasts with previous organizational structures far more pyramidal and highly parceled which tend to increase redundancy and have a smaller integration level. ERP's help to reach this structure is undeniable

8. CONCLUSIONS

The evolution of methods, techniques and tools to help the management of production systems through the XXth century have been induced and also have helped the evolution of organizational structures. Information integration, fast access to this data, the transparency and the definition of simpler and representative new measurement data, allow a high simplification of organizational structures, leading them to less pyramidal forms.

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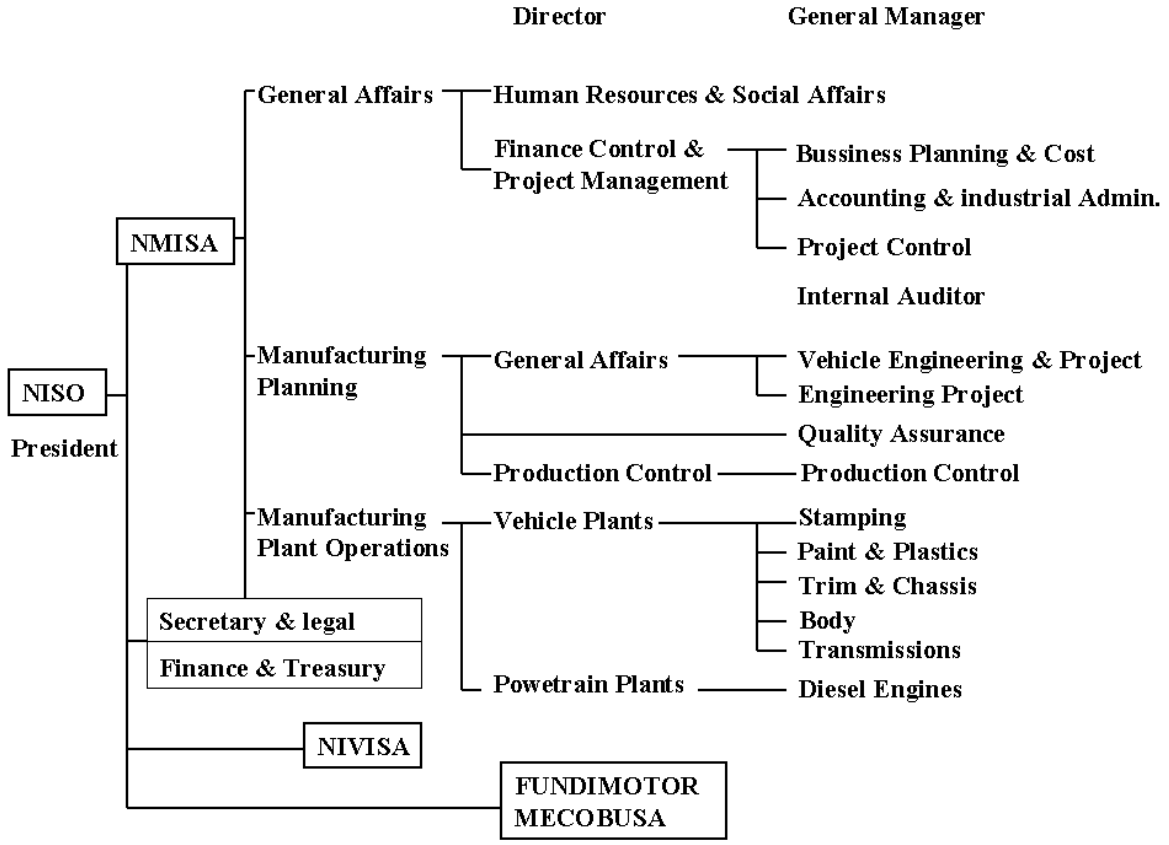

Figure 3: Current structure of a multinational company operating in Spain