INTEGRATION OF INFORMATION SYSTEMS IN MANUFACTURING

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Integration of Information Systems in Manufacturing

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Abstract

The value of storing manufacturing data electronically has been acepted by the quasi totality of the industry. The combination of expanding catalogue of softwares and less expensive hardware is making more comprehensive and integrated management communication systems technically feasible and economically justifiable. The benefits essentially stem from constructing a common database which contains a company's historical and up-to-date manufacturing information, and making this database easily accessible to all its potential users. The users might be in production, engineering, sales, marketing, distribution, finance, personnel, or other functions in the company. They could also be top management. Each user can add relevant data to the database and have rapid access to the latest information needed for preparing own reports. As such, all users have access to an integrated set of data which is internally consistent and is updated simultaneously for everyone. There are, clearly, great promises.

But how are the manufacturing companies around the globe reacting to these promises? Specifically, what are the areas on which they are concentrating their efforts? The purpose in this paper is to address these questions. In answering these questions we rely primarily on the results of a recent survey of 560 manufacturers in Europe, North America and Japan. There are intriguing singularities and differences in the three regions.

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Introduction

Most early computerized information systems in manufacturing were reflections of the manual processing, planning and control systems in which each application or task was processed separately by use of separate files. The systems for inventory control, production planning, scheduling and control, shop floor control, logistics, or quality assurance were usually developed separately and were built up around their own files. The separation of databases was even more pronounced for the computer supported links between manufacturing and engineering (e.g., with the early computer aided design systems) or with accounting and finance.

Thanks to the increasing capacity and performance of the computers of all sizes--from micros to big mainframes--we are now witnessing a distinct and forceful trend towards integration of information systems within manufacturing as well as between manufacturing and other functional areas in the company. The various islands of automated information processing and decision support systems have been continuously integrated to form broader systems. A clear starting point has been the introduction of materials requirements planning software packages which reconcile demand management with resource availability to plan long-term and short-term capacities and schedule production runs.(1) The subsequent steps in integrating the information systems within areas directly related to manufacture, however, do not seem to follow a clear pattern: some of the systems seem to focus on reporting the productivity of people and machines, some on quality, some on maintenance, some on procurement, and some on the efficiency of the various stages of

production process. Integration of all these system within the manufacturing function is clearly an outstanding challenge.(2)

In linking with other fucntions, the pattern of integration seem to vary rather substantially. The more recent manufacturing sofware packages also produce a limited number of financial reports (e.g., billing, payables, costing, inventory evaluation, capital budgeting, investment audit). But, in spite of the fact that the origin for many of the financial transactions is essentially in manufacturing--e. g., orders produced, materials used, labor hours spent, etc.-- the full integration of databases for the finance function and the manufacturing function does not seem to be wide spread yet. This presents another challenge.

Sales and marketing, too, provide a great deal of input to the manufacturing database, and need quick access to it routinely. But organizational considerations seem to dictate the sort of software which are put in place for facilitating these transactions. The issues here are a) to what extent marketing and sales data can be fed to the manufacturing database, (e.g., at the extreme, have the actual sales at the retail level be fed to the manufacturing database on real-time basis), and b) to what extent sales and marketing can delve into the common manufacturing database and change things (e.g., at the extreme, promise a delivery date to a customer and schedule the order directly on the production schedule). Such integrated information systems are likely to put the organisation on uncharted courses. This poses yet another challenge--one with exciting possibilities.(4)

Integration of design, engineering, and production databases poses a somewhat different challenge. The emphasis here is to provide primarily technical information for technical people. The emphasis in many of the above systems, in contrast, is to provide **managerial** information. Perhaps this is one reason why in many companies we observe sophisticated design and engineering databases and separate,equally sophisticated, manufacturing databases, with almost no links between the two. Not being a primary customer, the top management might have felt the benefits of such complex data integration would not justify its costs. The exceptions are found in those industries where the technical reasons dictate the link (e.g., design and manufacture of microprocessors),or the technical advantages are easy to see and valued greately (e.g., aerospace industry). The challenge here is to be imaginatve in transforming the technical advantages which such linking of databases offer into competitive advantages in the marketplace.

Together, these are among the principal challenges on the road which leads to computer-integrated-manufacture (C.I.M.).

Though one might be able to design ideal C.I.M. systems and dream about the automated factories, it will undoubtedly take a lot of effort to get from the present-day dispersed systems to some level of integration. (3) In most of the cases one may assume that integrated information systems will be developed incrementally. Defied by the opportunities and challenges created by the

technological possibilities, operations management and the informations group have to take some difficult and far-reaching decisons on how to plan the integration. (5)

To support these decisions it is helpful to understand which integration paths other companies have decided to pursue. The results of the survey presented here can provide some insight into this.

The Survey

Since 1982 an annual survey of large manufacturers in Europe, North America and Japan has been administered by means of a questionnaire issued by three research institutions in the respective regions : INSEAD, Fontainebleay, France (where the authors conduct the European Survey), Boston University, Boston, USA (where Professors J.G. Miller and T.E. Vollmann conduct the North American Survey) and Waseda University, Tokyo, Japan (where Professor J. Nakane conducts the Japanese Survey). The purpose of the survey is to develop a database on a variety of issues relevant to manufacturing management in each region, and to make triad comparisons of the trends in the three regions.(1)

The data presented in this paper come from the 1984 survey. About 560 manufacturers participated in this survey. One hundred fifty-two of them were manufacturers in the UK, France, Germany, Belgium, Italy, Spain, Sweden, The Netherlands, Switzerland, Denmark and Norway; 214 were in North America (United States and Canada), and 198 in Japan. The executives who answered the questionaires were mostly senior manufacturing managers, or otherwise were at a high level in the organisation. They represented a wide variety of industries, including food products, chemicals, machinery, electrical equipment,electronics, and automotive assembly. None of the industries represents more than 20% of the sample.

Several questions in the questionaire were related to the subject of this paper. Some of them were aimed at guaging the overall emphasis that the company was placing on the integration of information systems within manufacturing and accross functions. Other questions delved into details of the pattern of integration of the information subsystems in the past year and in the next two years.

Results and Discussion

A first question which arises is whether integration of information systems is perceived to be of high priority by the respondents. Out of a list of 39 specific actions related to a broad variety of issues in operations management, the respondents could check into which of these they had put effort in the past year, and into which they planned to put efforts in the next two

years.. Integrating manufacturing information systems and integrating information systems across functions were two of the actions out of the list of thirty-nine. Table 1 shows the rank order of these two actions for past and future efforts.

TAKE IN TABLE 1 : PRIORITY OF INTEGRATION OF INFORMATION SYSTEMS

Integration of manufacturing sytems was 8th on the list of past efforts for the European respondents, but has climbed to the 4th place for the future efforts. The rise of integration across functions is even more spectacular : from the 17th to the 5th place! The North American and Japanese data show the same trend. In all three regions manufacturers are placing more emphasis on the integration of information systems. However, in a relative sense, the Japanese are placing less priority on these activities than Europeans and Americans. They either have other priorities or they may be concentrating on the development of the information subsystems--such as for production and inventory control--first, before they venture into broader integration projects.

Nevertheless, there is little doubt that in all three regions more management attention is being paid to integration of information systems.

A second issue relates to the pattern of integration: considering the multitude of information subsystems which can be integrated within manufacturing and between manufacturing and other functions, which ones are receiving more attention? Are there any differences between the three regions? A section of the questionaire addressed this issue.

The section consisted of a multiple part question which asked hat degree of emphasis the company intended to place in the next two years on better integration of a set of 21 information subsystems. The list is shown in Table 2. The degree of emphasis was to be indicated on a continuous scale marked from no emphasis to small, moderate, significant, and critical emphasis. For the processing of the results, the answers were translated onto a linear scale from 10 to 50.

TAKE IN TABLE 2 : LIST OF INFO SUBSYSTEMS

Table 3 shows the five information subsystems which are receiving the highest emphasis for integration from the "typical" manufacturer in each region.

Table 4 shows the five least emphasized subsystems in each region.

TAKE IN TABLE 3 : INFORMATION SUBSYSTEMS WHICH ARE THE MOST EMPHASIZED WITH RESPECT TO INTEGRATION.

TABLE 4 INFORMATION SUBSYSTEMS WHICH ARE LEAST EMPHASIZED WITH RESPECT TO INTEGRATION

Manufacturers in all three regions agree quite convincingly on the importance of integrating quality control data with other

subsystems. There seems to be also agreement on the importance of integration of the traditional production planning and control information subsystems: materials requirements planning scores high in Europe and North America and master production scheduling (which may or may not imply an M.R.P. package) is high on the list of Japanese and Americans.

The differences in the three regions, however, are rather intriguing. The Europeans, on average, place quite an emphasis on the integration of sales related information systems. These same systems appear, however, in the Japanese data as the least emphasized for integration. The underlying pattern of the Japanese efforts can be characterized by an emphasis on the integration of process control information; rather different from Europe where still integration of computer aided design and manufacture--two process related subsystems-- are in the bottom of the priority list, and rather closer to North America where the priority of shop floor and material flow controls are more pronounced.

In the Japanese list the high priority of cost accounting is also noteworthy (Table 3). This might, in a first approach, contradict the relatively low rank given to the integration of the financial performance reporting (Table 4). One might, however, hypothesize that this reflects a bottom-up approach, starting on the shop floor and with the nuts and bolts of cost accounting, in contrast to a top-down approach, which would be reflected much more in the financial performance reporting.

The general picture which seems to emerge from the data is that, with respect to integration of information subsystems, the

Europeans seem to favour a top-down approach, starting with strategic planning and sales-related issues, whereas the North American and Japanese favor a bottom-up approach, starting with a down-to-earth shop floor control, inventory status and cost accounting. Typical in the Japanese results is the emphasis on integrating the technical side of the business with the simple management systems, which might be a reflection of their continuous strive for marginal improvements in manufacturing. (6)

A third issue is related to the co-variation among the variables: Were there any significant relationships in the emphasis placed on the integration of these 21 subsystems? For this issue, we analyzed the European data only. A factor analysis was executed to try to find out along which dimensions the co-variance could be explained.
Sixty-six percent of the variance in the total European sample could be explained by six factors. These are (in order of importance):

1. Sales forecasting and planning
2. Financial reporting and budgetting
3. Materials requirements planning
4. Process control
5. CAD and CAM
6. Design and Manufacturing Engineering

In other words, if one is looking for differences between European companies with respect to the emphasis they place on the

integration of information systems, then the most important factor is the one which is related to sales forecasting and planning: some companies place a high emphasis on the integration of sales forecasting and control, others pay far less attention to this. The same holds true, but in decreasing importance, for the five other factors.

Once one has come to this conclusion, it is of course interesting to find out what are the characteristics of the companies which haveplaced high or low emphasis on each of these six factors. The questionaire, in its entirety, provides enough data to draw a manufacturing profile of each of the companies and allows theoretically to describe the manufacturing profile with a high or low emphasis on each of these six factors. However, in this paper these manufacturing profiles will be presented only as tentative, since the database of 152 companies in the Euopean sample is rather small for this analysis; moreover, we could not control for the "noise" in the data-- e.g. the influence of promotion compaigns of software houses in particular countries. Consequently the reader should see the following statements as suggestions to stimulate further inquiries on the topic. Having said this, the results of our analysis can be summarized in the following statements:

1. The companies which emphasize as competitive priorities the ability to offer low prices, to make rapid design changes and the ability to offer consistent quality put a high emphasis on the integration of sales forecasting and planning with other information subsystems. It appears that low profit margins or markets characterized by rapid product design changes make

good sales forecasting more crucial.

2. Integration of financial reporting and budgetting is emphasized by those companies which emphasize high performance products as a competitive weapon.

3. Integration of M.R.P. systems is emphasized by those companies that emphasize as a competitive tool either rapid design changes or consistent quality and the ability to offer high performance products or want to make dependable delivery promises. Also interesting is that integration of M.R.P. is emphasized by those companies that pursue the development of new products for existing as well as for new markets. This might indicate that they hope to overcome the difficulty of the M.R.P systems in coping with new products by integrating more data from other information subsystems into the M.R.P. package.

4. Integration of process control is emphasized by those companies with a production process which is close to continuous flow production, but also by those that emphasize fast delivery as a competitive tool.

5. Integration of CAD-CAM is related to the production of one-of-a-kind capital goods, and especially in those industries where the ability to offer low prices is important to compete successfully.

6. And finally integration of manufacturing engineering is emphasized by those business units that are trying to enter new markets with existing products as a strategic direction, and those that want to do this by relying on high performance products.

Conclusion

Our survey of 560 manufacturing companies in Europe, North America and Japan supports the hypothesis that integration of information systems within manufacturing and between manufacturing and other functions is a growing concern. In all three regions management is paying increasing attention to this issue, although in Japan it does not appear to be yet as important or receiving the same priority as in the other two regions. Japanese manufacturers are probably still working on the development of individual components of an integrated information system.

The pattern of integration of the various information subsystems, however, differs from region to region. The European respondents seem to favour more strongly a "top-down" approach, while the North American and Japanese respondents seem to prefer a "bottom-up" approach. In developing their integrated manufacturing information systems, the North Americans seem to be more concerned with control of materials flow, the Europeans with demand management. Japanese manufacturers are more concerned with technical and engineering issues. All three, however, are unanimous in putting the integration of quality related data with other information subsystems in a very high priority.

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6. For more details see R.H. Hayes and S.C. Wheelwright "Restoring our Competitive Edge : Competing through Manufacturing", John Wiley and Sons, 1984.

Table 1

Priority of integration of information systems

(Rank order on a list of 39 improvement efforts)

		Europe	North America	Japan
PAST	Within manufacturing	8	7	25
	Across functions	17	20	36
FUTURE	Within manufacturing	4	3	10
	Across functions	5	9	27

Table 2
Complete list of information systems presented to the respondents

Master Production Scheduling	Materials Requirements Planning
Inventory Status	Shop Floor Control
Purchasing	Design Engineering
Manufacturing Engineering	CAD
CAM	Process Control
Quality Control	Maintenance
Cost Accounting	Financial Performance Reporting
Budgeting	Strategic Planning
Order Entry	Sales Forecasting
Sales Planning and Analysis	Physical Distribution
Market Research	

Table 3

Information subsystems which are the most emphasized with respect to integration

EUROPE	U.S.	JAPAN
Quality control	Quality control	Quality control
Strategic planning	Inventory status	Cost accounting
Sales forecasting	Master production scheduling	Shop floor control
Sales planning and analysis	Materials requirements planning	Master production scheduling
Materials requirements planning	Shop floor control	Process control

Table 4

Information subsystems which are least emphasized with respect to integration

EUROPE	U.S.	JAPAN
CAD	Physical distribution	Market Research
CAM	Maintenance	Maintenance
Maintenance	Market Research	Financial Performance Reporting
Order Entry	Budgeting	Order entry
Physical distribution and analysis	Order entry	Sales planning

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