INVITED PAPER

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From CIM to Global Manufacturing

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Abstract

The objectives of this paper are to show the evolution of CIM Systems, mainly in the Western Countries from the end of the seventies till now and the influence of the economic situation.

At the end of the seventies, the development of CIM was push by the technology. The result was a high level of investment and a low level of return on investment. The reason was mainly the inadequacy of the proposed solutions in comparison with the requirements. At the end of the eighties, the new economic situation changed the attitude : a contrario from the previous one, the problems pull the technical solutions in the factory combined with a reorganisation of the physical flow in order to introduce the Just In Time philosophy. Today, again due to the world wide facilities, we see a new paradigm : the Global Manufacturing in terms of market and of production of goods.

Key Word

CIM, Integration, Global Manufacturing.

1 INTRODUCTION

The objectives of this paper are to show the evolution of the CIM concept from the end of the seventies till now taking in account the strong pressure of the economic situation. This analysis of the evolution is more oriented towards the western countries but now, it seems the difference with the far eastern countries is becoming smaller.

In a first part, we will describe the situation at the end of the seventies when the evolution of the market influenced strongly the evolution of the industrial enterprises.

Since the end of the seventies, the market and the Industrial Enterprises have evolved. First, the level of competitiveness increased with the appearance of new competitors coming from new geographical area. Then, customer has become more and more exigent, searching cheapest

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products with appropriate quality, in shortest lead time. This evolution implied a lot of changes concerning the manufacturing systems : level of automation, advanced production management, quality, level of integration....

In this time, the development of information technology in industries led to CIM concepts implementation. This was considered as key element for competitiveness improvement, allowing shorter product life cycles, reduced costs.... At the end of the eighties, the new level of competitiveness and the economic difficulties led the Industrial Enterprises to search new techniques abd new methods more compatible with economic and human aspects. This new situation changed the CIM concepts. At the end, we will described the present situation with a new evolution based on a world-wide extension.

2 COMPUTER INTEGRATED MANUFACTURING (CIM) AT THE END OF THE SEVENTIES

At the end of the seventies, the increasing of the competitors number and of the customers wishes led to a complex market. On one side, the customer wanted customised products especially adapted to its needs. On the other side, due to the fact that the innovation transfer time decreased, the result was a great diversification in term of products and a stronger competition due to the saturation of the market.

To face to the new situation, the industrial world invested massively in the automation and the information technology. The Computer Integrated Techniques were created. The only problem was that in this time, the users, based on the assertion of the specialists, believed that the word COMPUTER can solve all the problems.

E. MERCHANT [Merchant 88], who was certainly the first researcher presenting the "Manufacturing System" in the sixties, defines CIM on this way : "CIM is a term coined to represent the full range of the capability potential which the digital computers holds for manufacturing". Figures 1 illustrates this definition.

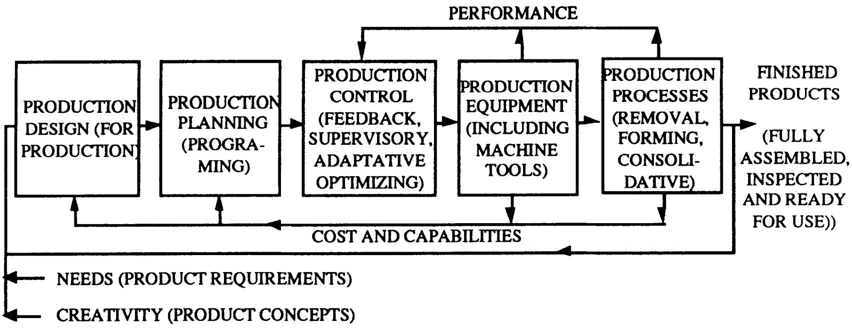

Figure 1 Computer Integrated Manufacturing System on MERCHANT point of view

Certainly this view of CIM was the earliest view. In 1984, G. DOUMEINGTS [Doumeingts 84] proposed an equivalent definition. He looked on the integration of all functions from the design of the product to its delivery with six major functions (figure 2) : Computer Aided Design, Computer Aided Manufacturing, Computer Aided Equipment Control, Computer Aided Production Management, Computer Aided Quality, Computer Aided Maintenance.

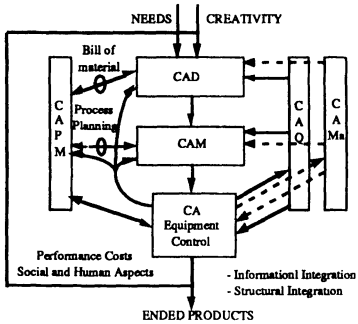

Figure 2 CIM on DOUMEINGTS point of view.

The main features of this system is the double integration :

❐ Integration by information : it exists a massive exchange of information between the various functions. For example the process planning produced by CAM is one of the basic information used by CAPM, Bill of Material produced by CAD is also used by CAPM for MRP function, etc... But the exchange of information between functions is not direct. This information must be transformed : it is impossible to use Process Planning in CAPM, as it is created in CAM function.

❐ Integration by structure : the structure of one function interferes with the structure of one another. It is typically the case with the planning of maintenance and the scheduling : the first must be taken into account by the second and vice versa.

The first CIM framework was proposed but despite the enthusiasm of the people for these CIM techniques, the integration was not a success. Indeed, the main preoccupation of the engineers and researchers was the development of Automation Systems. Blinded by technical challenges, they gave priority to Information Technologies and Automation. They did not take into account essential views such as social and human aspects, cost considerations, integration, etc... It was the great period of the FMS (Flexible Manufacturing Systems) and the UNMANNED Factory.

Led by the challenge of the full automation, the engineers forgotten that if we have to spend 20% of the investment to reach 80% of automation, it costs 80% of investment for the last 20% of automation. They were thinking only in term of investment (often very heavy), instead of thinking in term of return on investment. They forgot that the functioning of any system depends on the performances of its worse part.

Major other enterprises developed their own CIM project during the eighties : CATERPILLAR, John DEERE in US, Citroën in Meudon, Renault in Boutheon in France, ... If these projects were technical success, the resulting systems were not as performant as industrialists enjoyed. These first projects missed experience. There was a lack of global view and studies were not complete. For example, one failed because the ground couldn't support the AGV (Automated Guided Vehicle) implementing by the company. An other company didn't take into account the electric contacts robustness of the automatized mechanism it developed.

We will recall the excellent paper published in 1983 by J. HATVANY [Hatvany 1983] "Dreams, Nightmare and reality". We think this paper helped seriously the industries to understand that the most important in such domain is to analyse and to understand the problems.

We want to mention an excellent project in France in 1985 : SNECMA Le Creusot, in which the human and economic point of views were taken in account beside the technical one. In this big project (70 millions of dollars), the GRAI method allowed to define the specifications of the factory control.

Anyway, the eighties saw the birth of highly automated Manufacturing Systems but also the inadequacy between objectives and the means to reach them.

3 CIM AT THE END OF EIGHTIES

At the end of the eighties, a new economic situation appeared. This was characterised by the growth of economic difficulties. So, it implied to take care seriously to the amount of money spent in investment. About all, the exigence coming from the market was stronger : more diversify products in less time !!!.

The economic pressure obliged also the company to consider the performance of the enterprise as the combination of three major criteria : cost, quality and lead time. Then, the improvement of the manufacturing system performance led to optimise the triplet [cost, quality, lead time].

In order to manage these changes, several solutions were proposed.

The first solution was to increase the anticipation capacity. This led the enterprises to have a strong policy oriented toward market and products, to have a high modularity of products with common components and a very homogeneous sector of activities. It is why the enterprises evolved from an economy of scale to an economy of scope with coherence in the investments, in technologies and in knowledge, and with a good adaptation to the market : the companies focused on their core business.

The second one was to increase the adaptation capacity. This led the companies to have either an over-capacity or to develop a flexible manufacturing system.

The third solution was the improvement of product flow control. This led the enterprises to have a complete integrated manufacturing control system. This integration had to be implement from the design to the delivery of the product (Figure 3) and through the various decision levels from the strategic to the operational level.

These solutions imply to reorganize the manufacturing structure, to simplify the procedures and to improve the level of integration. Unfortunately, in this time, the integration was only at the technical level. It was necessary to develop new architecture at the conceptual in order to reach this situation. Due to the fact it is necessary to find, in a short time, the right solution to solve the identified problem, it is necessary to use not only architecture but also methodology to design and specify the solutions and to elaborate the specifications book in order to limit the risk of inadequacy between solution and problems. GIM (Grai Integrated Methodology) was one Methodology developed through ESPRIT Projects to answer to the industrial situation.

Moreover, in order to verify the achievement of the new objectives of these manufacturing systems, there was a need for performance measurement. This measurement was realised by the definition and the implementation of Performance Indicators Systems.

So, the new definition of CIM became:

"CIM stands for global methodological approach in the enterprise in order to improve the competitiveness of industrial enterprises.

This methodological approach is applied to all activities from the customer (product idea) to the customer (delivery of product), in an integrated way, using various methods and means (techniques, computers, automatic control)... in order to ensure simultaneously :

- productivity improvement,
- cost reduction, , increasing, ,
- fulfilment of lead times,
- quality of product,
- global or local flexibility of manufacturing system

In such an approach, the economic, social and human aspects have a place as important as the technical aspects.

So, according to this definition, the new manufacturing systems took in account not only the technical side but also the environment, the economic and the human aspects. :

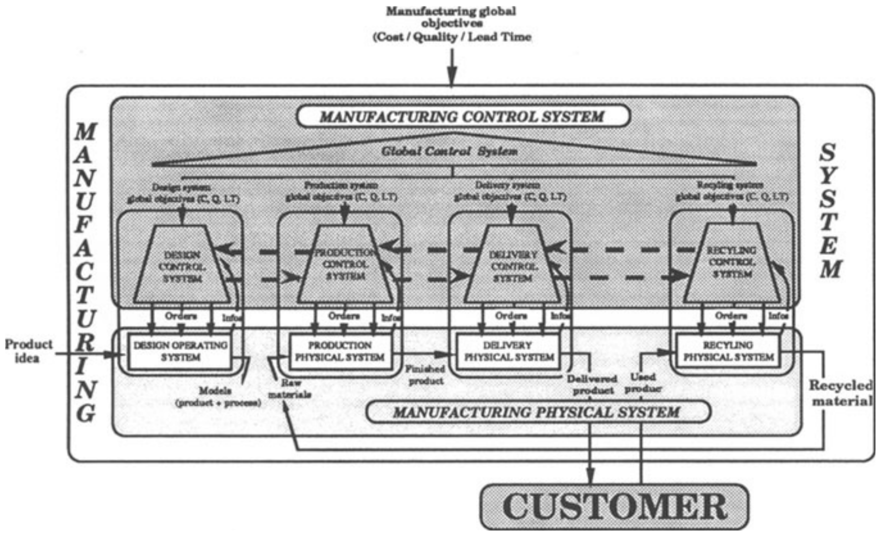

Figure 3 The integrated manufacturing system.

4 TOWARDS THE GLOBAL MANUFACTURING

During the last years, the market features evolved towards a internationalisation of exchanges. If the industrial enterprises can sell their products simultaneously in several regions around the world, the competitiveness level becomes more and more high. The industries are obliged to improve continuously their performances towards the optimisation of the triplet (Cost, Quality, Lead Time) for products and services. This new situation implies that the industrial enterprises design, develop, manufacture and distribute their products with a global point of view, searching appropriate partners in order to reach the performance level.

This manufacturing globalisation has two mains requirements for the considered enterprises. The first is linked to the building of a set of enterprises which create a chain from the design to the delivery of the products. These enterprises allow, by their abilities and their performances, to fulfil the customer needs at a minimum cost, with a appropriate quality and a short lead-time

[Doumeingts 1995]. This set forms a sort of "Virtual Enterprise" existing temporarily and in which it is necessary to develop the inter-enterprise relationships.

The second requirement is linked to the management of this "virtual enterprise". It consists to extend the concepts of integration, appeared in CIM approaches, to this set of enterprises located around the world (Figure 4). This integration is difficult because it must be realised in a distributed environment.

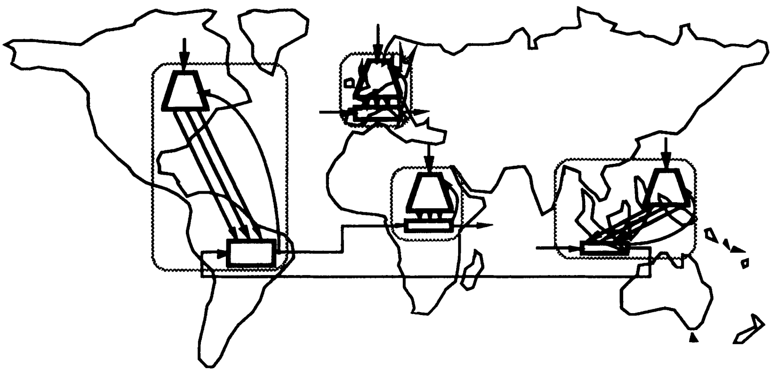

Figure 4 The Global Manufacturing System.

Regarding to this evolution towards globalisation of Manufacturing, several research projects were launched in which the GRAI/LAP is or was involved.

One of those, called "GLOBEMAN 21 : Enterprise integration for GLOBal MANufacturing towards the 21st Century" was developed in the frame of an international programme : IMS (Intelligent Manufacturing Systems). This project involving more than twenty partners (Europe, United States, Japan, Canada, Australia) was launched in March 1993.

During its feasibility study of one year, the objective was twofold:
- to perform a comparative analysis of current practices in order to determine the "good practices" related to four kinds of production (one off, small and large batch, continuous / semi-continuous) and simultaneously for six regions around the world (Japan, Europe, EFTA, Canada, USA, Australia). This study had to bring to the fore the cultural, technological and economical influences on the performances of the production systems,
- to determine, with the help of this comparative study, the research topics to promote in global production for the next ten years (horizon of the IMS programme) and which will support the future objectives of this project.

Based on the GRAI model [Doumeingts 84] and on the ECOGRAI method [Bitton 1990], a methodology to analyse and to compare the set of enterprises was developed. It includes three parts : a model and a formalism to describe the industrial practices, a structured approach to collect the data, several methods to analyse these practices and to derive the "Good Industrial Practices" [Doumeingts 1994].

The model is composed of three axes (figure 5): the managerial axis, the production axis, the evolution axis.

The managerial axis is decomposed in three levels : strategic, tactical and operational. The production axis is decomposed in various functions of product life cycle. The evolution axis contains two status:

- the current practice matrix (AS IS)
- the future practice matrix (TO BE) wished by the industrial partners.

So, for each function of the production axis and for each level of the managerial axis one identifies the objective, the drivers, the performance indicators and the boundary conditions (figure 5). This form the formalism : the Matrix (Figure 5)

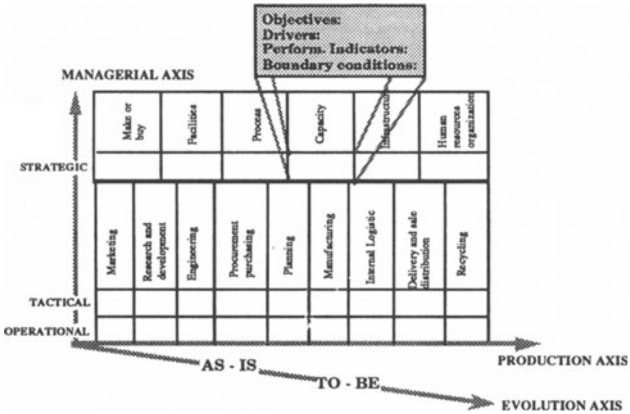

Figure 5 The Matrix.

In order to analysed the collected data and to derive the "Good Industrial Practices", four research centres have developed processing methods: "Coherence and Practice Analysis" developed by the GRAI/LAP and based on the coherence analysis of the various industrial practices inside the Matrix, "Cluster/Factor analysis" developed by Virginia University and based on the practices similarities study, "Profile analysis" developed by HUT and based on the QFD method, "Vizualisation" developed by CSIRO and allowing to vizualise graphically the Good Practices identified by GRAI/LAP. Finally, in order to derive the future research topics in Information Technology, Tokyo University developed an analysis method based on a deeper description of the Drivers.

This methodology was applied to 21 existing production systems related to 16 industrial partners. These 21 matrices (AS IS) were analysed with the five processing methods developed in the project. The synthesis of the results highlighted a set of "Good Industrial Practices".

In parallel, for each of the four domains, the future practices wished by the industrial partners were described with the TO BE matrix. The comparison between the AS IS and the TO BE matrices allowed to bring to the fore the future needs and also the future research topics.

Moreover, for each domain, the industrial partners identified the future research areas related to their type of production according the problematic of the globalisation.

One can also mention the Eureka TIME project (Tools and methods for the Integration and for the Management of Evolution of industrials firms) [TIME 93] in which the GRAI/LAP is also involved and which associates, at the European level, industrial enterprises and Research Centres of six countries (France, Portugal, Italy, Norway, Sweden, Finland). The objectives of this project are to develop methods and associated computer tools, to help the enterprises to place in the global market and to manage their evolution in order to adapt continuously. They can be classified into four categories.

The first one consists in providing a vision and an understanding on the new manufacturing management taking into account the continuous change of the economic environment. This new manufacturing management must allow the managers to elaborate and to implement a continuous strategic evolution.

The second one is to elaborate a methodology and supporting tools to implement this strategic evolution in the company.

The methodology must help the company :

- to define its Manufacturing Strategy,
- to elaborate the Evolution Procedures,
- to implement them.

The third one is to test, to improve and to finalise this methodology and the supporting tools, for relevant industrial situations, for various classes of manufacturing systems, based on the industrial partners involved in the project.

This experimentation will allow to provide several reference models, structured by type of problematic encountered.

The fourth one is to define a structure allowing to collect the evaluation reports of industrial companies, to determine the "Industrial Best Practices" at a European level and to provide anonymously the results by category of Reference Models.

Figure 6 shows all these conceptual elements.

The main phases of the evolution process appear :

- the system "as is", description of the present situation of the industrial system as well as of its environment, and the "mastered as is", obtained by eliminating deviations from the standard in the functioning of the system,
- the "should be" system, set of Objectives and Key Success Factors, which indicates the direction to follow and channels the evolution,
- the "next step" phase, which is the next steady stage reached from the initial situation ("as is") in the continuous improvement process towards the "should be",
- the action plan, set of actions to undergo and of guidelines to follow along the evolution path, allowing to evolve from one steady state to another.

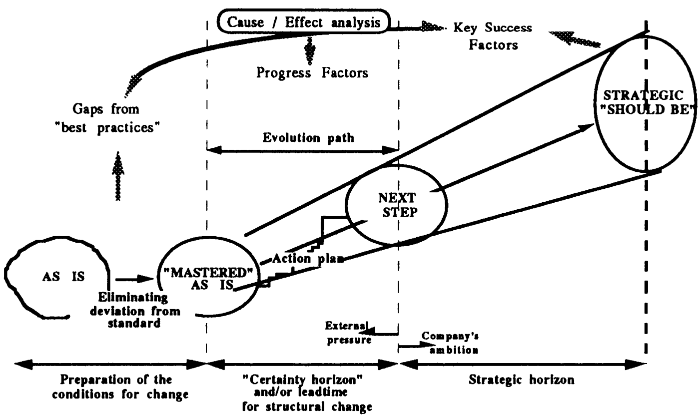

Figure 6 The TIME GUIDE model : Guiding the development of industrial enterprises.

The evolution process of industrial companies is undertaken as a project including five main phases (Figure 7).

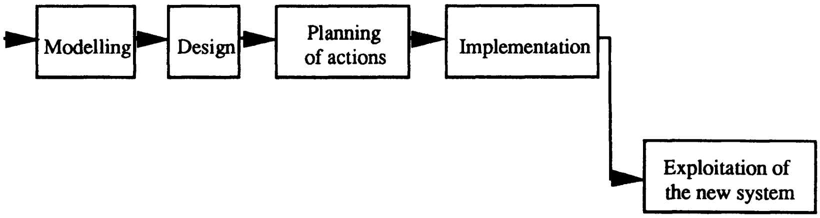

Figure 7 Main steps of a project

GIM (GRAI Integrated Methodology) is a method which allows to cover modelling and design steps. The term method means that GIM is composed of :

- conceptual models,
- structured approach,
- formalisms.

The modelling part of GIM allows to identify the elements of the "as is" system and their connections. It has to take into account both internal components and market-oriented issues (the company's customers, suppliers and competitors). GIM design step allows to design the model of the future system. Thanks to an user oriented approach, GIM allows to perform a model which is in total coherence with the user's needs. Moreover, it allows to take into account other essential elements such as the objectives of the enterprise, the present position of the enterprise on its market, the position of its competitors, some unconsistencies in the system, etc... To ensure the good appropriateness between objectives and means, GIM supports during modelling and design steps data providing by several additional tools such as self-audit tools or benchmarking tools.

5 CONCLUSION

If the CIM concept was strongly developed during the eighties in order to answer to the evolution of the market, it highlighted some limits. In particular, it led to build automatized systems without a real integration, to spend lot of money without thinking about the return on investment and to have a too important level of automation in industry without taking into account the human factors. It is why the end of the eighties, due to new economical difficulties, led the companies to answer exactly to the problems to solve with using in particular new methodologies and architectures to specify, to design and to implement manufacturing systems. With the use of these methods, the need for performance measurement highlighted to verify the achievement of the manufacturing systems objectives. Today, the manufacturing systems must be global, with several entities distributed in different environments, and completely integrated, from the design of the product to its delivery. The new problem which must be solved is the management of such global systems, how to control them, how to measure their global performances and how to make them evolve. The development of elaborated methods with associated computerized tools will allow to answer to this situation.

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