

Development of a method to evaluate the State-Of-The-Art in advanced manufacturing. Its application in the Basque Country

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Abstract

This paper shows the results of a research project that, founded by the Industry Department of the Basque Government, aimed at developing a methodology to measure the level of Advanced Manufacturing applied in Medium Sized Industries. This development has been applied in a collection of selected industries in the Basque Country in order to test the method and get a conclusion in order to be able to extend studies of this type to other collectives (geographical areas, industrial sectors, countries). The method itself, the way that it has been applied, its strong and weak points and final conclusions are commented on.

Keywords

benchmarking, advanced manufacturing, performance parameters

1 INTRODUCTION

Measuring Advanced Manufacturing (es: productica / fr: productique) on the threshold of the 21st. century involves much more than just talking about quantity; it involves measuring the quantity of CAD/CAM systems, robotics, FMS cells, management software or scheduling algorithms. Companies had already discovered that the introduction of a new technology or a new system does not necessarily involve an improvement of the global system. What is worse,

they know that if this technology does not match with the way that the company competes in the market, this future could be seriously endangered (see Senge).

These facts led us to focus the project on measuring technology investments and performance parameters, always with reference to competitiveness parameters (Riverola, J., 1991) (guía SPRI IKERLAN, 1995).

Following these guidelines, we defined the main tasks involved in the definition of the methodology. These are shown in Figure 1.

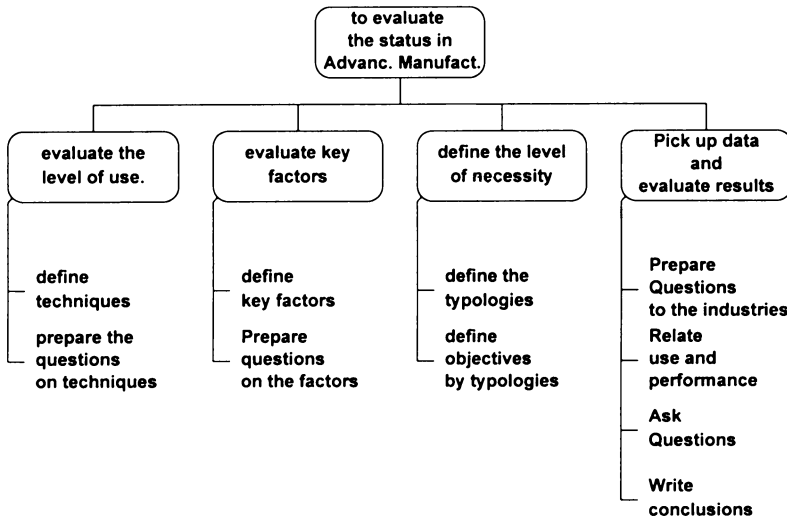


Figure 1 Activities involved in evaluating the use of Advanced Manufacturing

2 METHODOLOGY

This section provides a description of the method covering the steps, support techniques, support tools and documents which have been defined and developed.

Figure 2 provides the guide to be followed. The activities layout is represented with rectangles and the activities supported by each support tool developed in the project are highlighted with an arrow.

Now we are going to look in more depth at each activity, as well as the tools and techniques used and developed to support the method.

21 Steps

Some of the steps had to define the parameters to be measured and discuss the qualitative aspects. In those cases, using guides defined by DELPHI method (Gibson L.J. and Miller M.M., 1990), a group of Experts was established (Vincent-Wayne M., 1992).

- EVALUATE THE LEVEL OF USE: Measure the level of knowledge and use of the techniques in advanced manufacturing.
 - ⇒ DEFINE TECHNIQUES: The Group of Experts discussed, proposed and selected lists of the techniques and main concepts included in Advanced Manufacturing.
 - ⇒ PREPARE QUESTIONNAIRE ON TECHNIQUES: Prepare the group of questions to measure the techniques used in Advanced Manufacturing.

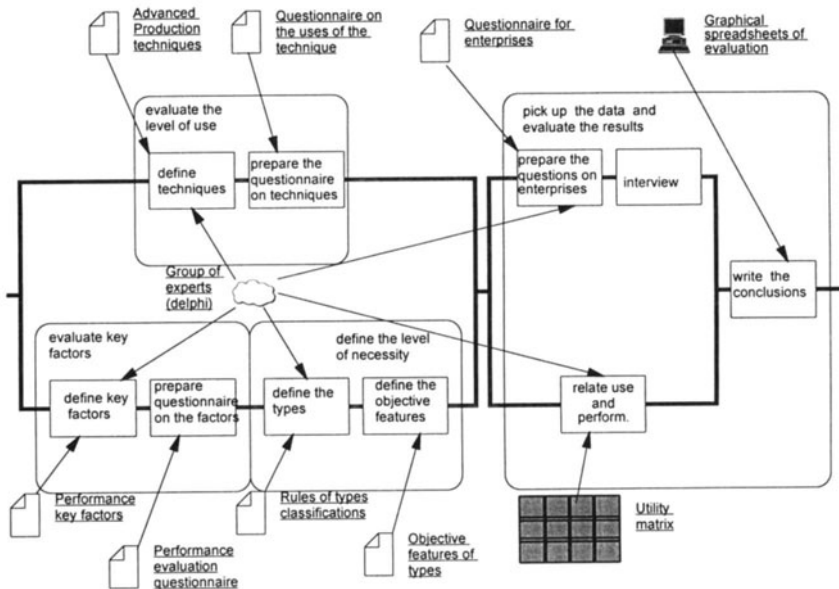


Figure 2 Outline of the Methodology

- EVALUATE THE LEVEL OF UTILITY: Evaluate the usefulness by comparing current performance with the best performance. As we see later, a definition of key reference factors that depends on the type of manufacturing strategy for the market is needed.
 - EVALUATE KEY FACTORS. Define the key factors and the way to measure them.
 - ⇒ DEFINE KEY FACTORS: The Group of Experts discussed, proposed and selected lists of factors to be used to find out the levels of performance.
 - ⇒ PREPARE QUESTIONNAIRE ON FACTORS: Prepare the group of questions to measure the key factors that have been defined, using data available from industrial companies.
 - DEFINE THE LEVEL OF NECESSITY. Define a level of reference to compare the current situation.
 - ⇒ DEFINE TYPES: The Group of Experts discussed, proposed and selected groups of industrial enterprises with the same type of manufacturing strategy for the market.

- ⇒ DEFINE OBJECTIVE FEATURES: The Group of Experts defined a draft of references for each type.
- COLLECT THE DATA AND EVALUATE THE RESULTS: Use the techniques of interviewing and evaluate the results.
 - ⇒ PREPARE THE QUESTIONNAIRE FOR THE ENTERPRISES: Based on the two groups of questions (Adv. Manuf. Techniques and Key Factors) prepare a document for the enterprises. The questions are grouped much more by departments as this is the natural way to get information inside current organizations.
 - ⇒ INTERVIEW: It must be done by experts in Advanced Manufacturing.
 - ⇒ DO THE UTILITY MATRIX: With the support of the Group of Experts the matrix of impacts between techniques and key factors is defined. It is going to be used to obtain conclusions.
 - ⇒ WRITE THE CONCLUSIONS. A document with the results.

22 Support tools

Inside this concept of tools we have incorporated different supports to help implement the method like: questionnaires, software, statistic methods, methods for polling opinion, etc...

In this section a summary of the following list of tools is given:

1. - Group of Experts.
2. - Concepts in Advanced Production (techniques, methods,...).
3. - Questionnaire on the techniques uses.
4. - Key factors in production performance.
5. - Questionnaire on performance evaluation.
6. - Rules for type classification.
7. - Objective features for each type.
8. - Questionnaire for the enterprises.
9. - Utility matrix.
10. - Results evaluation graphs (Spreadsheet).

Group of Experts.

A group of experts from different departments of the research centers in the Basque Country was formed. These departments cover the following areas: Market research, Design, Robotics, Advanced Automation, Production system and Manufacturing and R+D strategy.

The work done by these people consisted in: defining techniques, defining key factors, defining typologies and reference objective features, validating the questionnaire on techniques and performance and discussing the conclusions.

Concepts in Advanced Production (techniques, methods,...).

The Group of Experts has defined Advanced Manufacturing, for the purposes of this project, as the set of methods, techniques and tools required to improve the competitiveness of industrial businesses, by increasing the performance of the Production System.

Therefore, the scope is limited to industrial businesses. Industrial businesses are defined as enterprises that satisfy the needs of the market, creating added value, transforming raw materials into finished products.

Advanced Manufacturing Techniques have been grouped according to level (strategic, tactical or executive).

- Techniques to support “to make”. These techniques especially affect the process.
The reference list is: Logistics, Production Management, Customerize, short term Design, short term Process Planning, short term CAM, Monitoring, Process Control, Handling and Transport, Flexible Cells, Numeric Control, PLCs, Purchasing, EDI direct, Data Exchange (IGES,VDA,...), DNC, Aut. Guided Vehic., LAN, Machine Maintenance.
- Techniques to support “how to make”. These techniques affect the relationship between product and process.
The reference list is: Simulation, CAE, Rational Design, Database for technical data, Redesigning techniques, Group Technology, Rapid Set-up (SMED), Fault Tolerance Systems, Decision Models, Maintain Predictive, Quality Procedures, Reengineering, JIT, Design for assembling, Design for manufacturing, AMFE, Concurrent Engineering.
- Techniques to support “what to make”. These techniques affect the functional definition of the product to satisfy the market. (Muñoz-Seca 1991).
The reference list is: Creative Design, Innovative Design, Long Term Research, QED, Target Costing, Value Analysis (as support for creative design) Benchmarking, Quality Assurance.

Questionnaire on the techniques used.

The main objective of this questionnaire is to find out how these techniques are used in enterprises.

A set of questions was prepared in order to test the level of usage of the techniques, methods and tools defined as Advanced Manufacturing.

Key factors in production performance.

The aim of the key factors is to measure the need for an improvement in competitiveness in industrial enterprises. It is very important to know:

- The level of competitiveness: to measure how much the enterprise has progressed due to the use advanced production techniques.
- If the improvement efforts are well focused.

In order to carry out this evaluation, three sets of factors that measure the position of industrial enterprises in advanced production have been defined (Zugasti, I., Beitialarrangoitia J.C., 1994):

- ⇒ Efficiency: measures the current performance with the current range and current production resources, (global efficiency, process efficiency).
- ⇒ Adequacy to the market: the current enterprise capacity to satisfy the market, (response time, extend range of products, and image and customer satisfaction).
- ⇒ Potential evolution: the development of new ideas in order to satisfy the market, (R+D, range renewal and financial potential).

Questionnaire on performance evaluation.

The aim of the project is to measure the current performance of enterprises. So we need to translate these key factors into some measurement factors which could be easily extracted from the companies' answers.

The measurement factors have been classified into the following sections: Finance, Design, Market, Production, Quality, Resources, Inventory and Time.

Rules for type classification.

A classification of the different types of enterprises has been made in order to do an evaluation, because we did not want to assume that all the enterprises in the same sector have the same structure and the same way of doing business. (Zugasti, I., Arregi, B., Martín, C. 1994).

An in-depth analysis of the reference types is necessary in order to group the enterprises, taking into account their homogeneity in the key factors.

The work has focused on the Basque Country because the aim is to analyze a concrete situation in reference to Advanced Production and Manufacturing.

Once the classification was made, the enterprises were divided into groups according to the following types:

⇒ Capital Goods A.

Characteristics: Own product, Design to order, Unitary manufacturing.

⇒ Capital Goods B.

Characteristics: Own product, Assembly to order, Unitary manufacturing or customized lot.

⇒ Consumer Goods A.

Characteristics: Own product, Assembly Orientated, Lost manufacturing, can be variants.

⇒ Consumer Goods B.

Characteristics: Own product, Manufacturing Orientated, Lost manufacturing.

⇒ Components A.

Characteristics: Own product, Assembly Orientated.

⇒ Components B.

Characteristics: Own product, Manufacturing Orientated.

⇒ Subcontracts.

Characteristics: Components without own product, Subcontracting of manufacturing services.

⇒ Continuous production

Characteristics: Manufacturing Orientated.

Objective features for each type.

The objective features for each type have been defined. The importance the key factors may have in each type has been evaluated by the group of experts. This evaluation is done with a maximum score of seven and a minimum of one.

The optimum condition will be the maximum score in all the key factors for all types, but we think that in order to be competitive in the market, some types have to be stronger in some factors and less strong in others depending on the characteristics.

These key factors, types and scores were placed into matrixes and graphs where the objective features can be easily studied.

Type features can be seen in the Figure 3, where the factors used are as follows:

- Global efficiency: measures production system global performance parameters like turnover, total depreciation, no quality costs,
- Manufacturing efficiency: measures business process efficiency like process capacity, flow control,
- Inbound logistics: measures the suppliers response, raw material stockouts, supplying efficiency.
- Outbound logistics: measures the delivery efficiency, finish product stockouts.
- Design: measures the design efficacy, reutilisation of designs.
- Response time: measures the production system response according to customer needs like system adequacy.
- Range of product: measures how much objective market spans the enterprises, the internationalization level,...
- Image and customer satisfaction: measures the good customer service aspects like new customers, market share, service time,
- R+D: measures the enterprise potential in research and development like R+D efficiency, R+D subcontracted,...
- Range renewal: measures the enterprise's activities in order to launch new products like percentage of new products in one year, mean life of products.
- Financial potential: measures the enterprise's financial position in order to tackle future achievements.

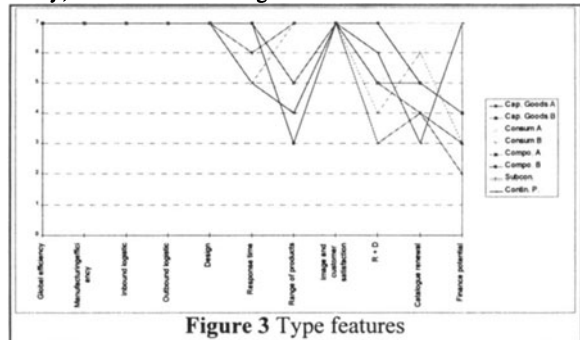


Figure 3 Type features

Questionnaire for the enterprises.

A questionnaire was prepared for enterprises based on the Advanced Manufacturing Techniques and the Key Factors.

This questionnaire consists of general enterprise data and 121 questions grouped by departments: general data (6 questions), finance (9 questions), quality (12 questions), manufacturing (49 questions), time (10 questions), design (10 questions) and research and market (19 questions).

Utility matrix.

The work done in this project has been represented in a matrix in which the techniques, methods and tools of Advanced Production have been arranged according to the key factors. The advanced Production techniques with the questions that evaluate their usage in the enterprises are placed on the horizontal axis.

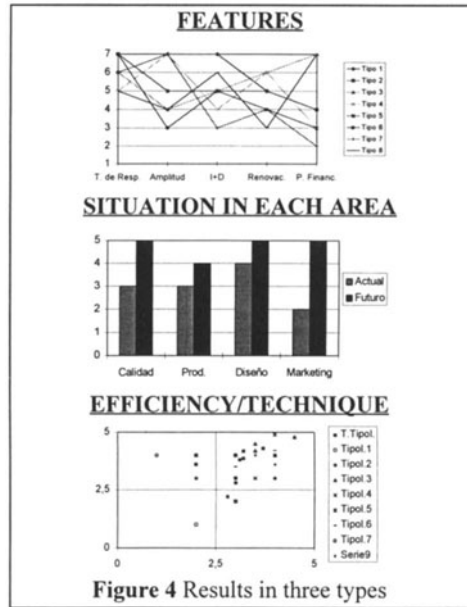
The key competitiveness factors that the techniques may improve are placed on the vertical axis together with the questions used to evaluate the necessity of improvements in the key factors.

Results evaluation graphs (Spreadsheet).

Once the representative enterprises for the Basque Country were selected and the data collection carried out, some of the results were taken out.

The results are shown in three types of different graphs, see Figure 4:

- ⇒ *Features*: features of the results for each type of enterprise
- ⇒ *Situation in each area*: current and future situation of techniques in each company department
- ⇒ *Efficiency/Technique*: correlation between effort and results in each type of enterprise.



3 EXPERIENCE

This method has been used to measure the level of Advanced Manufacturing in the Basque Country. This use has been quite restricted in the scope of the project because the budget and the completion date required were not compatible with exhaustive benchmarking. The project started on 20 July 1994, and finished on 31 December 1996. During the project there were two main reasons that made complete benchmarking difficult:

- a) The specific nature of the set of questions demanded that the inquirer had to be well prepared to answer all kind of doubts. In practice, this required that the members working on the definition of the method had to support the survey. So the scheduled subcontracting of the survey was not possible.
- b) The measurement and comparison of performance factors, called key factors, segmented the collective of industries into eight different groups of performance strategy. Thus, the scheduled collection of fifty industries had to be changed to two hundred.

The method has proved to be very well structured and the results of the survey show that the expected reference (best practice) shape defined by the experts using Delphi matched the collected data. You can see two shapes in Figure 5 and Figure 6.

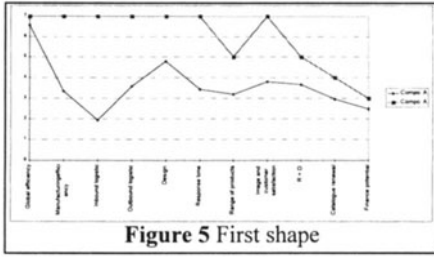


Figure 5 First shape

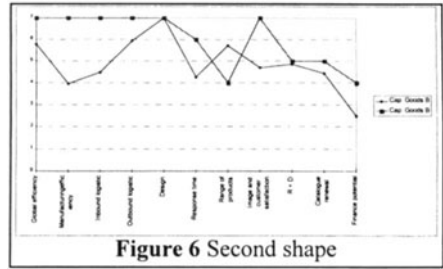


Figure 6 Second shape

One of the best pieces of work was the development of formulas to convert data concerning industries with different size, different business figures, into comparable performance parameters. The typology and the key factor concepts proved to be very useful.

4 CONCLUSIONS OF THE SURVEY

The study lead to an interesting set of conclusions about the industries in the Basque Country. In this paper we will illustrate some of them in Figures 7 to 10.

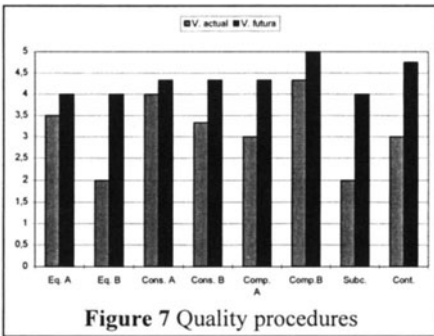


Figure 7 Quality procedures

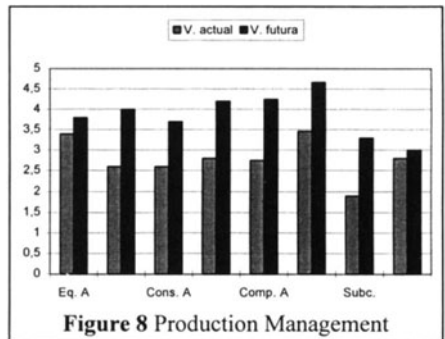


Figure 8 Production Management

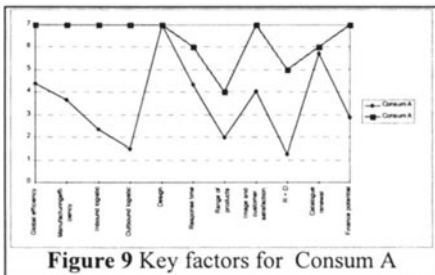


Figure 9 Key factors for Consum A

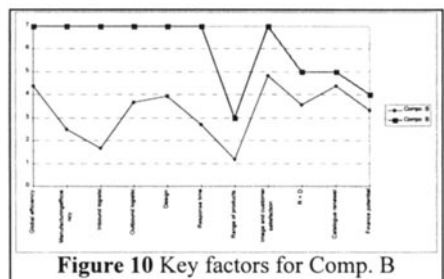


Figure 10 Key factors for Comp. B

- Figure 7 - Quality procedures. This Figure shows a comparison between current and future levels for each defined typology. The need for improvements in Quality Procedures is widely accepted in many of the typologies. Three of them have a good level, Capital Goods A (as a result of Machine Tools industries), Consumer Goods A (Automotive and

Electronics) and Components B (as a result of Automotive Components industries). (Goenaga, J.M., Pagalday, G., Zugasti, I.).

- Figure 8 - Production Management. This Figure shows a comparison between current and future levels for each defined typology. The need for improvements in Production Management is widely accepted in many of the typologies. We can see that in Continue Production the level of automation leads to simple Production Management. Also Capital Goods have a greater need for techniques in Design than in Production Management.
- Figure 9 - Key factors for Consumer Goods A. This Figure shows a comparison between the reference factors defined for this typology with the average of the collected data. We see that these industries perform well in design but not so well in R+D and Outbound Logistics.
- Figure 10 - Key factors for Comp. B. This Figure shows a comparison between the reference factors defined for this typology with the average of the collected data. We see that Inbound logistics is a good opportunity for improvement. Global efficiency leads to a very small range of products.

5 USING BENCHMARKING TO MAKE A RAPID DIAGNOSTICS IN SME'S

The performance parameters were collected systematically from January 1995 in those enterprises in which IKERLAN carries out the diagnostics of the Production System. The data base includes about 50 enterprises that

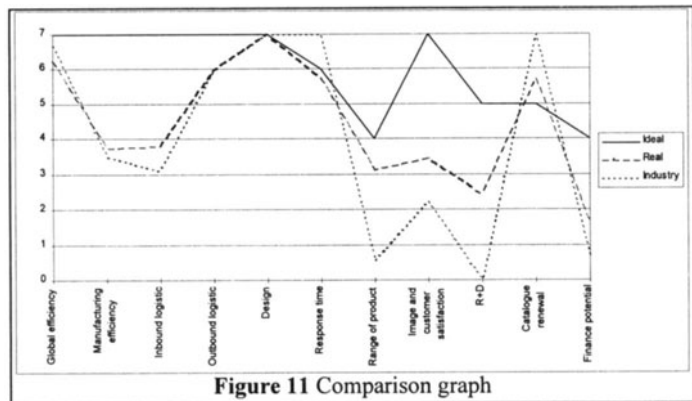


Figure 11 Comparison graph

belong to different production types (Capital Goods A, Capital Goods B, Consumer Goods A, Consumer Goods B, Components A, Components B, Subcontracts, Continuous production). Now we show the steps followed and the results of one of them, that is grouped in the Capital Goods A typology.

These are the steps to be followed:

- Questionnaire (General Manager / 2 hours maximum, 1h:20min average).
- Brainstorming (General Manager, Production Director, Quality Director / 2 hours).
- Video and Photo session (Production Director / 1 hour)
- Study of data collected and conclusions (Ikerlan / 8 hours)

In Figure 11 you can see the comparison graph. The most important conclusions of the comparison made with the database of the Capital Goods A type are as follows:

- **Global efficiency**, measured by the relation between the no quality costs and the added value in production and the relation between turnover and resource costs (labor + depreciation), is higher than the mean.

This high value is due to a good product-market, by contrast the flow efficiency parameters are not very good. We kept the good design of the product in the visit video and the overall brainstorming session.

- **Inbound logistics**, which measures the supply efficiency, is quite below the mean. This is coherent with the problems maintained during the brainstorming session where a need for a radical decrease in the lack of material had been noticed (from 6% below to 1%).
- The lowest value in the efficiency of the **operations** is due to the current situation of low work-load.
- In the same way, we can see in the **outbound logistics** parameter that there is more stock of finish products than usual in these production types.
- The result of the **delivery time** parameter is important. In general, the delivery time fits with the market needs in spite of the existing problems in the inbound logistics. This is coherent with the overall impression of a radical decrease in the lead time not being possible.
- Finally, we must point out the poor result of the **extend range of products** and the **catalogue renewal**. This means that if there are potential customers who could be approached using current technology resources a better activity in new products is going to be very profitable.

6 FINAL CONCLUSION: KEEPING LIFE BENCHMARKING.

As you probably know this kind of effort to prepare such advanced benchmarking is very important. The main question is how to maintain a good reference for future diagnostics. We have been doing some work during 1995 to improve the results of the methodology:

- We have been collecting more data from our diagnostics with industries
- The improvement of the Questionnaire having continuous contacts with other benchmarking work (TIME, 1995).
- Use collected data to review performance references of typologies.

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8 BIOGRAPHY

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