

**SWP 34/90 COMPUTER INTEGRATED MANUFACTURE (CIM) - BUY
NOW OR PAY LATER**

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CIM - Buy Now or Pay Later

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Accounting and Manufacturing: Allies or Rivals?

Introduction

The term "Computer Integrated Manufacture" (CIM) is now commonly used to describe the new and perhaps more socially acceptable face of manufacturing. The common perception of the factory of the future is one where arduous and repetitive tasks are performed by machines controlled by computers. However, much confusion reigns about the definitive interpretation of the term computer integrated manufacture. This is reflected in a recent report on "Integrated Manufacture" ¹ which lists and includes a discussion on six conflicting interpretations of the term CIM.

Against this background of confusion about the meaning of CIM there is also the general concern about the successful exploitation of advanced manufacturing technology. This can be best summed up by a remark once made by Georges Pompidou, ie. that there are three guaranteed ways of losing money - women, gambling and computers. Women are the most fun, but computers are the most certain.

There is therefore, the desired goal of automated production and the uncertainty of how to achieve it. The purpose of this paper is to present the case for striving to achieve CIM, and this will require definition, with a recommended approach for overcoming the latent apprehension of adopting such a strategy for manufacturing operations.

Computer Integrated Manufacture

For the purpose of this paper, computer integrated manufacture is defined as follows ²:

1. It is a system which encompasses all areas of business not just 'manufacturing' in its strictest sense.
2. It will not necessarily be totally computerised, but computers will play a major part in the system.
3. All organisational functions are integrated in a CIM system, so that information from one is readily accessible to another, subject to obvious security constraints.

This definition has been selected because it details the pervasive characteristic of a CIM system, ie. it is more a corporate than purely functional system. However, the definition does not clearly explain how a computer integrated manufacturing system is actually constructed. Consequently, such a definition alone will not help persuade the senior management of manufacturing businesses to develop a strategy to establish CIM. It is still not clear what CIM is.

To overcome this problem a 'generalised' model is shown in Figure 1. A number of models have been published ² but none were found to be particularly helpful when planning a CIM strategy for a new factory. The model shown in Figure 1 is still incomplete because it does not detail how computer technology can be exploited to

control manufacturing processes in the factory. This issue is discussed later in this paper.

Figure 1 is therefore, a model which attempts to provide an overview of computer integrated manufacture, i.e. how the strategy for such a system should originate and a simplified view of the information flows within the manufacturing organisation. The model is, by design, a simplified view and so it has limited value. Nevertheless, preparing a simple conceptual model of the CIM system designed for the new business helped with the following problems:

1. Explaining how information technology could be exploited in the future to those who have the problem of managing the business. It is essential that senior management can understand the presenter's view of computer integrated manufacture and, in particular, how such a strategy will provide competitive advantage. Dealing in such abstract terms as CIM requires a clear exposition on what is involved, the risks and the benefits.
2. The model showed an overview of the total system and therefore, the ultimate goal. The preparation of the model helped identify system design problems - for example, the management of quality control data.
3. The model was also used to plan the construction of the CIM system. It constituted the plan of the first stage of a longer term programme for the factory.

CIM - Why buy now?

During the last decade competition in the international markets for manufactured goods has intensified considerably, as expected. Only the most competitive survive.

The UK manufacturing industry has found it very difficult to cope with this increased competition and many have lost domestic market share to foreign competitors. This is a continuation of the loss of market share that the UK manufacturers had already experienced in export markets. The result of this lack of competitiveness is that the UK is now a net importer of manufactured goods for the first time since the industrial revolution.

The attack on the UK markets has been directed at all segments of the manufactured goods markets. In the markets for lower value added products, e.g. textiles and clothing, the source of the competition has been from businesses in the developing countries, where lower labour costs provide an opportunity to compete on price, particularly for products of labour intensive manufacturing activities. For the higher added value products, e.g. cars and high technology products, the source of the increased competition has been primarily from the Far East. The Japanese competitive strategy has been to be price competitive, to provide superior quality and product variety.

What will be the criteria for success during the next decade? It must be a continuation of improvements in customer service that have already proved to be successful and perhaps response time. It is clear that the most successful competitors search for new ways to stay ahead of their rivals and therefore, speed of response to customer demand provides another opportunity to continue to improve customer service. As George Stalk Jnr.³ states in his article on this subject:

"Today, time is on the cutting edge. The ways leading companies manage time - in production, in new product development and introduction, in sales and distribution - represent the most powerful new sources of competitive advantage".

Figure 2 shows how the Japanese competitive strategy for manufactured goods has changed as competition has increased. It is therefore essential for UK manufacturing companies to better the competitive strategy of their rivals, which means that they must compete on quality, variety, price and customer delivery lead time.

Much has been written on the management of quality and costs, but managing product variety and fast response are more recent issues. To achieve a competitive customer lead time will require effective throughput management.

One method of evaluating the competitiveness of a company in terms of its ability to provide a fast response to customer service is to use the throughput efficiency ratio. This is defined as follows:

$$\begin{array}{lcl} \text{Throughput efficiency} & & \text{setup times + manufacturing} \\ \text{of an order or batch} & = & \text{process times for the order or batch} \\ \text{of products} & & \text{Total in-plant manufacturing} \\ & & \text{lead time for the order or} \\ & & \text{batch of orders.} \end{array}$$

Therefore throughput efficiency is the proportion of the total manufacturing lead time which is usefully used for value added purposes. During the remainder of the time, costs are incurred by the company. A low throughput efficiency also indicates an inflexible production system.

What are the causes of an uncompetitive reaction time to changes in market demand? Primarily unproductive delays in the production system, i.e. where long and tedious procedures are necessary to change from the production of one type of product to another. In this type of environment large batch quantities are scheduled to minimise the productive time lost on machine changeovers. In addition, much time is wasted in the manufacturing lead time as parts queue in work in process between manufacturing operations.

Both of these causes of inflexibility refer to time and thus to correct inflexibility, management should direct its attention to the management of time in production. Whatever the nature of the manufacturing business, i.e. making for stock, or making to order, world class manufacturing will be achieved only by the ability to adapt quickly to changes in demand, to produce up to date information on market demand and the status of the resources used for production. The latter is needed to manage a quick response to changes in market demand.

Such a stratagem has been shown to be successful when competing in international markets for both the low value added and high value added products. An example of the adoption of this approach can be observed in the clothing industry, i.e. computer controlled dyeing plants have been sited in the developed economies, the raw material are sourced so that products and fibres can be dyed as the demand for coloured clothing changed. Point of sale data is transmitted to the distribution centres so that the manufacturer is almost immediately aware of any changes in product choice and can quickly respond accordingly. How can a manufacturer thousands of miles away from this market achieve the same speed of response to customer demand, except by producing in advance of demand. For fashion clothing with its unpredictable product life cycle, it is a strategy that cannot be bettered, unless the competitor has its own presence close to the potential customers.

For the high value added products, for example cars, product variety and speed of response are major weapons in the battle for customer demand. The 'Just in Time' method of production originated in this industry and therefore, all UK car manufacturers are now changing to this production management philosophy. Computer integrated manufacture is accepted as the means to reduce the product development to introduction time, the sales and distribution response times.

It seems that the combination of computer integrated manufacture and low inventory productions systems are a proven approach to manufacturing competitiveness and action is therefore required now. This is a medium term strategy for a manufacturing business and yet there is very little evidence that the UK manufacturing industry is placing much emphasis on adopting such a strategy at this time⁴. These results are in stark contrast to the research findings⁵ on the actions planned by Japanese production organisations in order to improve their manufacturing competitiveness, i.e. developing flexible manufacturing operations comes first on their list of priorities.

Experience has already shown that competitive advantage is a moving target and therefore, failure to anticipate competitors' changes in strategy and to outmanoeuvre them will result in the continued loss of market share. Failure to take action now, will result in management and employees in the UK manufacturing industries paying later.

A strategy for implementation

The reluctance to invest in computer integrated manufacture obviously cannot be explained by a general absence of a desire for excellence in manufacturing. However, an obstacle to adopting a CIM strategy for manufacturing is the difficulty with presenting the economic case for such an investment. Previous experience does not assist either, because research findings in the UK have shown that where the complexity of manufacturing technology has been increased, the financial success of such investments have decreased. These results should be interpreted with care, because of the current accounting systems' limitations at adequately measuring all the effects of such investments. This issue will be further discussed in the final section of this paper.

However, this same report¹ claims that major benefits can be achieved if CIM is adopted correctly. Benefits such as reductions in design costs of up to 30%, substantial reductions in manufacturing lead times, better quality etc.

Both statements are probably correct and perhaps attention to the two messages given will provide an appropriate strategy for implementing CIM and for managing the inherent technological risks. An overall strategy was therefore determined based upon the lessons learnt from previous research and Japanese manufacturing management methods.

The strategy consisted of the following:

1. Initial manufacturing operations should be as simple as possible in order to quickly learn how to produce the product efficiently. The JIT manufacturing management philosophy would be used.
2. The focused factory would be directed to a process focus i.e. final assembly and test only.
3. A computer integrated manufacturing objective would be established at the factory design stage so that the investments

made for initial production would be consistent with the longer term goal of CIM.

4. Technological risks would be minimised during the factory start-up phase in order to concentrate on the technology transfer problems of manufacturing a new product.
5. Fixed costs during start-up would also be carefully managed so that the market's acceptance of the product could be tested before longer term investments in manufacturing capacity are made.
6. If the volume of demand increases then make 'or buy' decisions will be reviewed on tasks requiring the use of known technologies.

A decision to make in-house would constitute establishing another plant-within-a-plant. The level of automation used for each of the islands of production would be assessed on normal economic criteria.

7. Total integration would be planned when the product design and the manufacturing process have become 'firm'.

The rationale for this gradual approach to CIM, is that there are many interrelated problems when managing the start-up of a new factory and each must be managed in a systematic way. The 'S' curve phenomenon, which shows the relationship between the effort put into improving a product or process and the results achieved over time, is a useful model for presenting the strategic case for investment in CIM and planning its implementation. Figure 3 shows the 'S' curve for manufacturing systems and technology. The figure shows the technological changes leading to CIM for a manufacturing company performing machining operations, but the model can also be applied to assembly operations. Figure 4 shows how this was used for the current factory design project.

The 'S' curve can be used to show how technological risks can be phased over time as the manufacturing system evolves. A rapid acceleration of technological complexity can overload the manufacturing management team especially when the constant problem of achieving the desired level of output is present. One critical limitation of this approach is that competitors actions may not permit the gradual approach and therefore, attention must always be paid to the window of time available to reach the full production of a new product.

The CIM development programme

The aims of adopting a progressive method of building a computer integrated manufacturing system were to spread both the management of the technological risks and the programme of investments. An overall design for the system (Figure 1) was prepared and this was agreed to be the ultimate goal. However, each step towards the goal would require an analysis of both the technological and financial risks. Figure 4 shows an overview of the steps to be taken as production volume increases but it does not itemise the elements of the CIM system. The planned CIM development programme was as follows:

1. Factory start-up phase
 - (a) Electronic Data Interchange links with suppliers.

- (b) Material Requirements planning system for:
 - (i) Order enquiry and delivery date estimating
 - (ii) Master production scheduling
 - (iii) Managing the supplies of bought-out items
 - (c) Shop floor data collection system.
2. Vertical Integration phase
- (a) Investment in a laser or gas cutting machine - Direct Numerical Control (DNC).
3. Automation phase
- (a) Robot welding
 - (b) Integration of two way communications with islands of automation in the factory.

The technological risks of each of these investments are relatively well understood because all of these innovative uses of technology have been individually applied previously.

However, the integration of the information systems to be used, during the start-up phase of the factory was a financial risk that did have to be evaluated. This was an unprecedented step for the company and therefore, it provided the risk management issue that could be used to determine an assessment procedure for subsequent CIM development decisions.

Financial justification for CIM

Kaplan ^{7,8} has argued that accounting systems developed in the early part of the twentieth century, when the competitive environment and manufacturing methods used were so different, are inappropriate for measuring the efficiency and effectiveness of manufacturing in today's competitive environment. The precept that he offers ⁸ is that the financial analysis should consist of not only the discounted cash flow of the easily quantified savings, but it should also include an estimate of the revenue enhancement expected from the investment. His recommended approach is to estimate the annual cash flows about which there is greatest confidence, the cost of the investment and the cost savings expected, i.e. labour, materials and space etc. Should the discounted cash flow be negative, then the proposal could still be acceptable if the value of the intangible benefits would raise the annual cash flows to give a positive net present value of the desired return.

It is the measurement of the intangible benefits that is the focus of the accounting profession at this time. Acceptance of Kaplan's approach is not universally accepted by the senior manager, who is indoctrinated by traditional methods of financial appraisal. The critical manufacturing performance objectives desired for this factory are quality and fast response to customer demand. The manufacturing system's attributes must, therefore, be increased throughput efficiency and action flexibility ⁹, i.e. the ability to leave options open so that it is possible to respond to change by taking appropriate action.

The procedure applied to prepare the financial justification was one which used the Kaplan methodology and it was complemented by using some of the concepts of throughput accounting.

The common characteristic of all the investment recommended for the initial development of the factory's CIM system is their use for inventory management. The target for the factory's manufacturing management is to achieve and sustain an annual inventory turn ratio of twenty five - which is twice that currently achieved in the company's other factories. This is essential if the objectives of fast throughput and flexibility are to be achieved. Such an objective is also consistent with the second concept of the new approach proposed to update traditional cost accounting methods, i.e. throughput accounting¹⁰. Concept 2 is defined as follows:

"For all businesses, profit is a function of the time taken for manufacturing to respond to the needs of the market. This in turn means that profitability is inversely proportional to the level of inventory in the system, since the response time is itself a function of all inventory."

Consequently, in addition to the cost benefit of a lower level of investment in inventories to that currently incurred, the company should become more profitable if this response time is quicker than its competitors.

A simplified example of the analysis of the tangible benefits is given on Appendix 1. Obviously not all potential cost savings have been shown but the net difference between the financial returns shown and the cost of capital used for the investment was approximately £100,000. The company management then had to decide whether they valued the intangible benefits of investing in this first stage of the CIM development programme at £100,000 or not, in the context of the competitive strategy of the business.

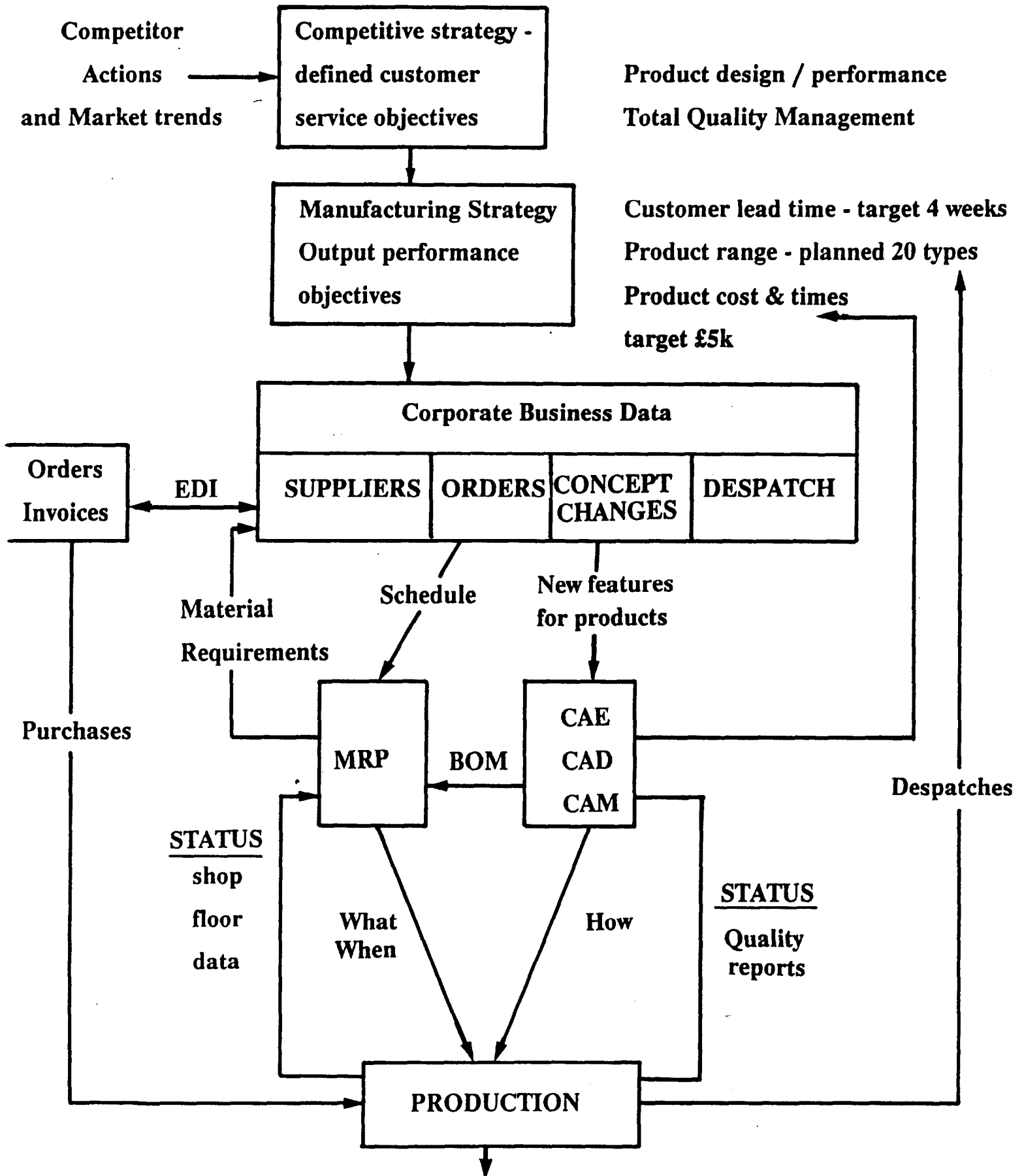
Conclusions

All changes in technology involve both financial and technological risks but equally a decision not to change is also risky. Investments must yield a return in excess of the cost of capital invested and a major intangible benefit is not losing competitive edge through failure to exploit new technology. The rate of technology take-up by international competitors requires the quick but carefully planned application of CIM.

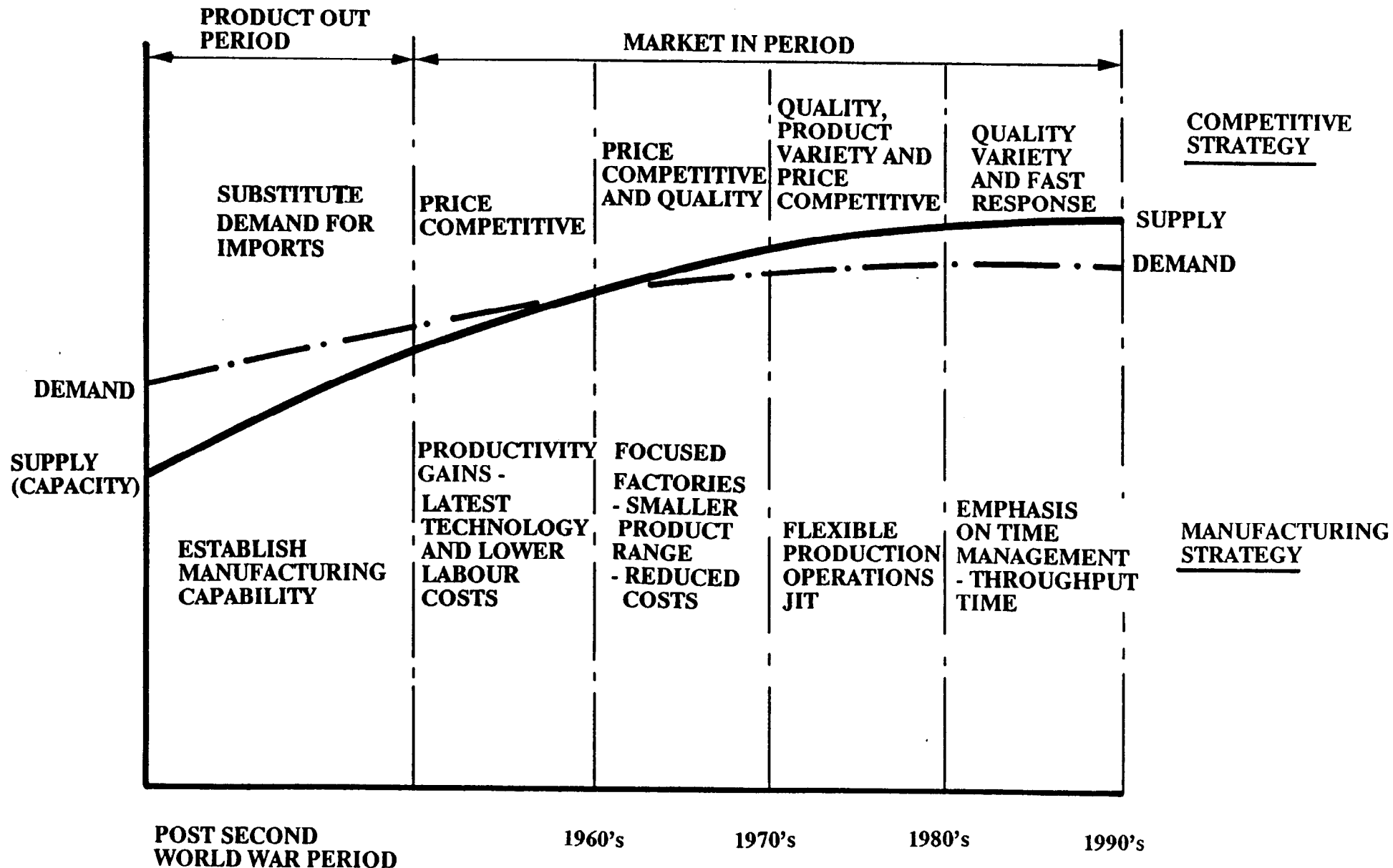
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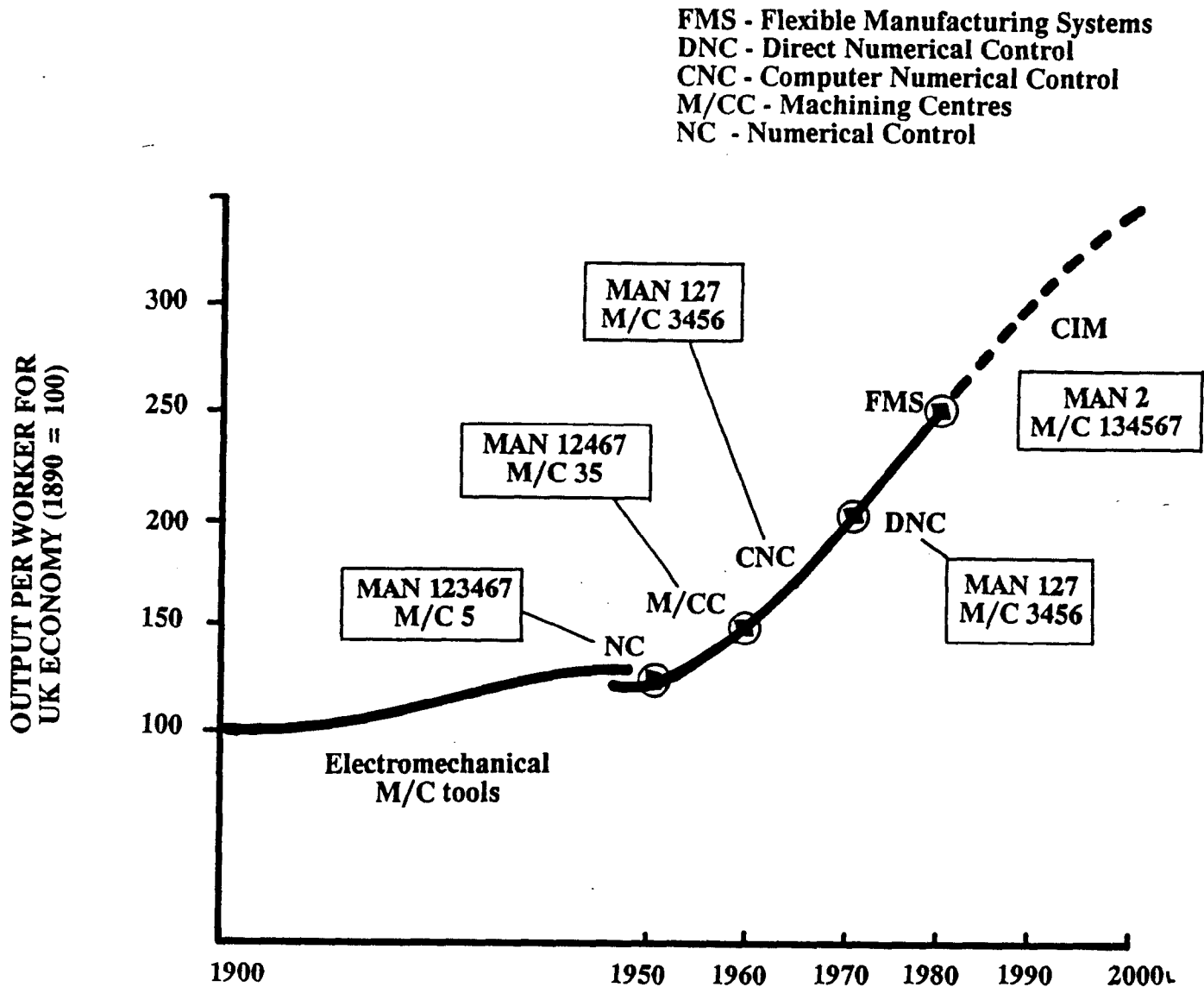
CIM MODEL



EVOLUTION OF JAPANESE COMPETITIVE STRATEGIES AND REQUIRED MANUF. STRATEGIES



MANUFACTURING PROCESS DEVELOPMENT



Tasks associated with M/C tool operation

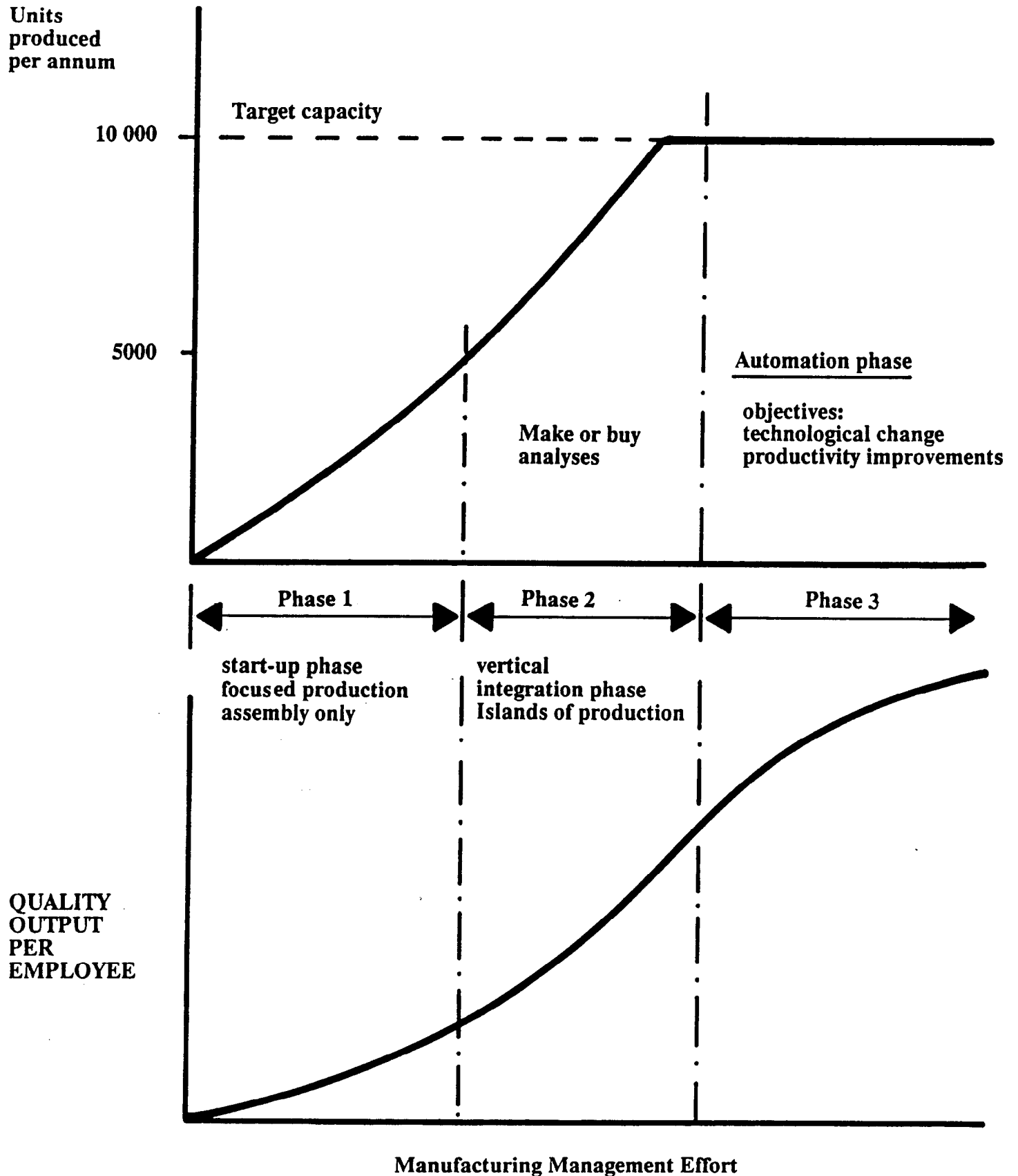
1. Movement of material to machine
2. Inspection
3. Selection of correct tool
4. Setting operating values
5. Control of machines motion
6. Sequence of further operations
7. Loading and unloading

FIGURE 3

(Adapted from toward the unmanned factory ⁶)

FIGURE 4

PRODUCTION OUTPUT PLAN



'S' curve for a manufacturing process

CIM Development Phase 1

Justification Analysis

Tangible benefits analysis

YR	Sales	12 Turns p.a. Inventory Investment	25 turns p.a. Inventory Investment	(A) Investment reduction	(B) Cost Savings
0					
1	£20m	£1.66m	£800k	£430k	£43k
2	£40m	£3.33m	£1.6m	£850k	(C) £21k
3	£60m	£5m	£2.4m	£1.3m	£22.5k
				Total	£86.5k

(A) Half the incremental growth is assumed to be the average working capital savings for each year.

(B) The cost of capital is assumed to be 10%.

(C) The incremental increase is only used for determining this saving in costs:
 $£850k - £430k = \frac{£420k}{2} = £210k$