

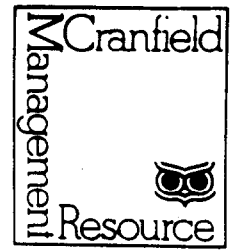


**SWP 54/87 UK MANUFACTURING: THE CHALLENGE
OF TRANSFORMATION**

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U.K. MANUFACTURING: THE CHALLENGE OF TRANSFORMATION

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1. THE CHALLENGE OF NEW TECHNOLOGY

The challenge of incorporating new developments in manufacturing technology into manufacturing strategy can be seen as the laying down of a series of major challenges to conventional manufacturing thinking:

1. Reduce Work in Process by 50% or more
2. Reduce lead times by 50% or more
3. Facilitate the introduction of new products at two to three times the existing rate on half the current design/development lead times.
4. Reduce "support" labour by 50% or more

It is not enough to think of mere "tinkering" with existing systems and technologies, such radical changes require a totally novel approach. Yet such an approach is perfectly feasible if one examines the current "norms" for manufacturing in most engineering companies, even those with relatively high volume final assembly processes. The normal conditions are:

- . Bought out content 50%
- . Throughput efficiency in component manufacturing, that is the ratio of work content to total lead time of 20%(or 80% of the time queuing or idle)
- . Throughput efficiency relatively high in final assembly.
- . Additionally we need to recognise: extensive periods in materials stores, finished component stores and often finished goods stores.

Any approach which can reduce the "idle" time spent in the system will in fact achieve the first three objectives automatically and is likely to make labour reductions far easier to accomplish. However, instead of concerning itself with the "idle" portions of time productivity, most Western management seems to have been concerned with the (much smaller) "busy" periods, that is with concentration on the actual work task. While this is clearly not to be ignored it seems to have been a case of not seeing the wood for the trees.

2. SOME ALTERNATIVE APPROACHES TO IMPROVING TIME PRODUCTIVITY IN MANUFACTURING

2.1. The Japanese (Just-in-Time) Approach

This involves tight control over the flow of orders through the system to maintain very low queues. It requires considerable delegation to operators, a very directed application of manufacturing engineering to reduce set-up time and high levels of commitment to continuous and relatively constant production. Even the Japanese have only been able to apply this approach in a limited range of industrial environments but these have shown major benefits.

A European version of this courage + control + people-power approach can be seen in the application of Group Technology principles, which incidentally are very much the current vogue in the U.S. despite their relatively unfashionable image in the U.K.

2.2. The Systems Intensive Approach

The more usual Western approach has been through sophisticated data processing systems in order to "solve" the manufacturing problem. This involves extensive data collection and daily scheduling of every operation. While this approach seems to have been more broadly applicable than the JIT approach, its effects have been far less dramatic: a move from "one operation per week" to two or three operations per week" is certainly an advantage but it may still mean only say 10 hours work in a 40 hour week, a throughput efficiency of only 25%.

2.3. The Capital Intensive Approach

The use of capital investment in high technology manufacturing equipment in order to effect time productivity is not new. It started with multi-axis machining centres and other multi-operation machines, the objective being to reduce the number of operations, the ultimate aim being one operation per part. Too often, however, the promise was unfulfilled because although 10 components of a 100 component assembly were produced in 4 weeks instead of 14 the other 90 still took 14 with no effect on the customer lead time. Alternatively, the planners went overboard in putting as many components as possible on such machines only to generate bottlenecks ahead of them. The successful application of the capital intensive approach requires a plant wide view to be taken and careful planning of capacity.

2.4. The Time Intensive Approach

This simple approach has often been neglected; multi-shift operation is a very effective method for shortening the total elapsed lead time, since throughput efficiency relates hours of work to available hours. Thus at an efficiency of 25%, 100 hours work would take 10 weeks at 40 hours per week but only 5 weeks at 80 hours per week on a 2 shift basis.

The likely impact of the newest manufacturing technologies can best be understood by seeing them as providing the vehicle through which all of the four fundamental approaches described above can be implemented simultaneously:

- (a) Just-in-time production is made possible through few operations, tight deterministic scheduling and minimum tool change times.
- (b) Again because of the high level of predictability obtained and the reduction in lot sizes close coordination of component requirements is not only necessary but is also significantly facilitated.
- (c) The solution is clearly part of the capital intensive approach but it is important to re-emphasise the point that it must be a plant wide view that is taken in the overall system design.

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- (d) Multiple (unmanned) shift operation becomes a reality.

3. COMPUTER INTEGRATED MANUFACTURING

The complete CIM model includes at least the following major modules:

3.1. Computer Aided Design (CAD)

This includes the production of schematic drawings and detail dimensioning and may include finite element analysis and simulation capabilities.

3.2. Computer Aided Production Engineering (CAPE)

The CAPE module in general accepts data from the CAD module and from this process routings, operation lists and times can be produced. In addition it will normally include provision for tooling and the design of jigs and fixtures. CAPE would also usually produce the necessary computer control instructions/tapes for both manufacturing machines and test equipment.

3.3. Computer Aided Production Planning (CAPP)

The CAPP module is probably the most familiar and has been around for some time in the form of computer scheduling systems. CAPP takes inputs from CAPE and the order acceptance systems and using its own basic data carries out load and capacity planning and detailed scheduling.

3.4. Computer Aided Manufacturing (CAM)

Although, used in a general sense this may include everything except CAD, it is convenient to regard the CAM module as only carrying out those activities directly related to machining processes. CAM therefore operates the production machines and carries out real time job sequencing.

3.5. Computer Aided Storage and Transport (CAST)

The final basic module is concerned with materials handling. This may include warehousing, automatic stock picking systems and materials conveyancing. It would also control any Automatic Guided Vehicles (AGV's) used within the manufacturing system.

The basic links between these modules are illustrated in Figure 1.

4. NEW TECHNOLOGY INVESTMENT IN THE U.K.

In a recent survey of U.K. manufacturing operations (New 1986), plants were questioned concerning their current and future plans relating to investments in the new manufacturing technologies.

For many of the plants the perceived payoffs to date from new technology seem to have been low or even non-existent. While this in itself should not be

surprising what is more worrying is that the failure to obtain short term results may be discouraging companies from pursuing these technologies further. If this view is carried through it spells disaster for the U.K. economy in the long run.

The 240 sample plants included 155 in engineering and related activities - the obvious major users of much of the available new technology. However, of the 64 plants reporting experimentation with Flexible Manufacturing Systems (FMS) technology, two-thirds reported low or negative payoff to date. Of the 69 experimenting with Robotics over three-quarters reported low or negative payoff. Taking CAD and CAM (Computer Aided Design and Manufacture) together, while two thirds of the companies who could possibly make good use of the technologies did in fact report using them, almost half did not think they had made any significant gains from their introduction. Tables 1 and 2 show for comparison the plants' ranking of the specified technologies on the basis of payoff to date and future emphasis.

In relation to planned future emphasis the results do appear to be slightly disturbing. Less than half the respondents intended to put high or even fairly high emphasis on CAD/CAM and this proportion dropped to 25% for FMS and a meagre 15% for Robotics - in fact around one in three reported NO emphasis on the latter two. Only the computerised production planning and control technology represented by MRP showed any real payoff to date or indication of extensive future emphasis: 56% of plants reported fairly high or high payoffs already and 79% intended putting that level of effort behind such systems over the next two years - good news for the computer companies and software houses.

The slightly encouraging side of the results is seen best from Table 3 which shows that there is at least a fairly dramatic increase in the number of plants intending to pick up the new technologies over the next 2 years. For example while only 64 plants reported themselves as using FMS technology to date, 115 reported some future emphasis (that is ranking its importance above 'none') indicating a 79% increase in take up. Similar increases are apparent for the other technologies. The technique showing the least percentage increase, MRP, was already being widely used.

4.1 Competitive Priorities

In terms of competitive strategy in the marketplace the current ranking of the 'competitive edge' criteria planned by the U.K. respondents is shown in Table 4. The degree of importance apparently attached to the top ranking items: consistent quality and dependable delivery is impressive. Almost three quarters of respondents ranked consistent quality as 'high', rising to 97% ranking it fairly high or high. Similarly 58% ranked dependable delivery as of high importance rising to 92% fairly high or high. There is of course some element of "motherhood" in such results - no one is likely to say such things are unimportant. However, if we compare the U.K. results with those from the European Futures Study (Ferdows, 1985) and from the North American Manufacturing Futures Survey (Miller and Vollman 1985) as shown in Figure 2. some interesting comparisons emerge.

The similarities are not surprising: consistent quality is clearly a number one priority in the U.K. as it is in the U.S.A. as it is in Europe. In second place for the U.K. and the U.S.A. comes dependable delivery, but

for the European sample as a whole the ability to produce high performance products was ranked higher than dependable delivery in 1983 and 1985 and equal with it in 1984. In fact as can be seen clearly in Figure 2 the U.K. rankings in absolute terms tended to be higher than for the U.S. or European sample except in two directly related areas: the ability to produce high performance products and even more markedly the ability to implement rapid product design changes. For the U.K. sample the ability to produce at low cost ranked higher than the ability to produce high performance products whereas in every case for the European surveys and for the U.S. this ranking was reversed.

This is a strange and worrying finding for a sample heavily biased towards the U.K. exporting industries. The emphasis in U.K. manufacturing is still apparently seen to be on the production of fairly standard products at low costs. It is clear that the developed economies of Europe are much more concerned with the rapid introduction of new high performance products than with low cost production - and this is almost certainly the only viable long term strategy for a highly developed economy. To be fair this trend was more marked in the consumer and intermediate product plants than in those producing capital equipment: while 74% of all plants rated low costs 'fairly high' or 'high' only 63% of the plants producing capital goods did.

The other striking feature of Figure 2 is the difference in the rating assigned to 'after sales service' between the U.K. and U.S. plants who rated it fairly important and the European plants who generally ranked it below any of the other criteria. Does this indicate a competitive weakness of European companies? This could possibly be exploited by U.K. manufacturers who are clearly aware of this factor's crucial importance, particularly in the capital goods field. In fact in the U.K. survey four out of five plants in the capital goods sector rated after sales service at the fairly high/high level.

One could perhaps argue that with less emphasis on new product development and design flexibility the U.K. plants perceive less of a requirement for some of the new technologies. However, some of the most important potential benefits to be gained from CAM, Robotics and FMS are likely to be in the areas of quality and delivery reliability, so this argument seems to be difficult to support in practice.

Returning to delivery reliability, it is clear that the plants all rated the ability to deliver on time to quoted delivery dates as a major competitive factor. Yet the reported delivery performance of the participating plants was actually fairly poor: almost one in four plants reported delivering less than half of their customers' orders on time. Setting a very modest target of "75% or better on time delivery" only 46% of the plants achieved this. Moreover, the proportions as we have seen are remarkably consistent between 1975 and 1985, in 1975 only 44% of plants achieved an on-time delivery target of 80% or better - plus ça change c'est la même chose! Again, in 1975 40% of plants reported that they had no formal system for measuring performance against promised delivery dates and this figure appears if anything to have gone up (to 46%) rather than down.

The situation which seems to emerge is one of 'lip service' to delivery reliability: the plants almost unanimously rate it as important but: one in four plants deliver more orders late than on time and the median plant in the sample delivers one order in every four after its originally quoted delivery date. Finally only about half the plants even bother to monitor their actual delivery performance. The strategy is good, the tactics simply don't deliver.

5. REASONS FOR THE U.K. INVESTMENT FAILURE

It is clear from the survey results reported above that there is a reluctance in the U.K. to invest even in the 'Islands of Technology' and consequently even more reluctance to move towards CIM.

If we consider a typical FMS capital expenditure proposal it is not hard to understand the reluctance of management to take up such investment:

	Conventional	FMS	Difference
Number of Machines	68	18	-78%
Number of Operators	215	12	-94%
Floor space M ²	9750	3000	-69%
Lead time (days)	80	3	-96%

This all looks very impressive and certainly from a labour productivity point of view it is. However, when we examine the expenditure requirements we find that the FMS requires something like an additional £13million up front capital investment and shows savings of the order of:

One off (Inventory reduction)	£2.8m
Annual (labour savings)	£1.0m

The result?

A DCF rate of return of less than 10% and a Payback period of 10 years. For a project which requires main board approval this is clearly an unlikely proposition.

The bald outline figures of this proposal provide all the clues as to why such investments appear unattractive and why U.K. management in particular have been slow in putting money into radically new technologies. Let us examine each of these in turn.

5.1. Inadequate Tools of Financial Analysis

(a) Use of Excessively High Hurdle Rates or Short Pay-Back Periods

Typically, companies require applicants for investment funds to produce a detailed DCF analysis for the proposed project and to submit this for consideration alongside other proposals. A 'hurdle' rate is established by the controlling function (usually the financial controller or accountant) and projects not getting over the hurdle are rejected. A less sophisticated management might require payback within a given time.

On the assumption (not necessarily true but not for discussion here) that capital is in short supply, management tend to set high hurdle rates in order to 'allocate' the available funds - to high return projects. Such hurdle rates are often of the order of 15 - 30% and may reflect the current return on assets being achieved.

Technically there are a number of problems with this approach. The major weakness is that a company's true hurdle rate is in fact its marginal opportunity cost of capital - in other words the real rate of return which could be obtained by investing the money in something else. This long term rate is around 8 - 10% NOT 15 - 30%. Moreover the problem is compounded by setting a high discount rate (which includes inflation) but using constant ;'s in the cash flow projections - a practice which is of course totally inconsistent. Such errors, even assuming the cash flow projections are complete, introduce a heavy bias against all forms of advanced technology investment because of:

- Long start-up periods
- Long project lives
- Delayed returns

Similar conditions apply in the case of short pay-back periods. How can an FMS which will take up to 2 years to fully implement pay back within 3 years from start-up - which actually implies a payback closer to one year.

The return on current assets is often used as the basis for the hurdle rate on the reasoning that any investment which does not show this return will dilute current return on assets. This is certainly true but is also irrelevant. If a company is making say 30% return on £1M of assets and invests a further £100,000 at say 10%, its return on assets will drop to 28% but if in order to do this it borrowed the £100,000 at a real cost of say 7% it is now making $10,000 - 7,000 = £3,000$ extra profit per annum. In other words companies give up extra profit in order to maintain an artificially high return on assets. In any case the main reasons for such returns is nothing to do with the profit being earned but rather with the low valuation of the current asset base.

(b) Use of Inappropriate Alternative Investment Assumptions

In preparing an investment proposal for new technologies it is often the case that the 'do nothing' option assumes future conditions of stable market share, selling prices and costs. Such assumptions clearly fail to take account of possible competitive action. If any one competitor in the market does make such new investment, over time such assumptions are unlikely to remain true. In most cases the new technologies provide a substantially lower marginal unit cost. In order to achieve a better return on the initial investment a competitor using the new technology is likely to use such cost advantage to increase market share.

It is obvious that such status-quo assumptions make new technology investment look less attractive. The true base-case comparison should probably be falling market share, falling sales and rising unit costs.

In the same way comparison of new technology investment with 'like-for-like' replacement often assumes an inappropriate life for the 'old' technology. Flexible manufacturing systems by their nature may be flexed to meet changing product requirements. Traditional forms of often product specific investment may have their true life limited by product changes - this is of course particularly important for high volume manufacturing businesses.

We have already discussed the use of high cut-off or hurdle rates but we should repeat again the fact that using a hurdle rate of 30% implies that there are alternative investment opportunities available which do give a real rate of return of 30%, this is simply not true.

(c) Bias Towards Incremental Investment

In most companies the Capital Expenditure proposal system is set up around authorisation levels: up to £10,000 might require department head approval, £30,000 plant manager approval and so on. It is therefore not uncommon to see clusters of proposals which manage to come in just below the established ceilings. This practice sets arbitrary limits on incremental investments and forces many junior managers (who raise the proposals) to think only in terms of such incremental investments.

It may well be that each incremental investment may apparently be justified in its own right, the problem is that added together the increments actually cause dysynergy and are certainly not as effective as a total innovation could have been. It is also not uncommon to discover that if, for example, all the inventory reductions claimed for each incremental investment were added up the company would have a negative inventory! As much post-investment auditing often shows the savings claimed in order to meet high hurdle rates simply do not materialise in practice.

Perhaps an even worse consequence for the company is that the existence of a whole set of ongoing incremental investments actually precludes consideration of revolutionary investment proposals. At any point in time there are a number of investments whose benefits are still outstanding and to abandon them in favour of a radical change clearly indicates that such investments should not have been started - that is an admission of error by the managers concerned. The correct strategy would appear to be to assess the technological life of the existing plant and only accept investments which show a return within that period - say 3 years. The intention of course being to replace the existing plant with a radically new technology at that time. Is that what U.K. plants are currently doing with their short payback requirements? Do they really intend to scrap their existing plants in 3 years anyway? I wish I believed that that were true.

(d) Failure to Include all Tangible Benefits

Typically investment proposals have included only the most obvious of the tangible benefits expected and only those which it has been possible to quantify easily. As it happens this did not matter very much before the advent of CAM/FMS systems simply because the changes were not dramatic enough. If a new machine requires say 25 M² instead of 30 M² the cost of the factory space was hardly very relevant. With FMS type systems, however, we are talking of space reductions of the order of 70% and inventory reductions of a similar order - these offer very real opportunities for cost reduction.

The tangible benefits which need to be accounted for certainly include:

- . INVENTORY REDUCTIONS in terms of investment savings and space and warehousing costs.
- . FLOOR SPACE REDUCTIONS taking into account the true opportunity cost of new space and such items as heating/lighting etc.
- . QUALITY IMPROVEMENTS, including the benefits of process repeatability and monitoring, waste reduction, inspection reduction and reduced warranty payments to customers.
- . WAGE INFLATION PROTECTION, the far lower number of people involved in running the new technologies clearly provides considerable protection against general wage inflation. In a sense the plant is able to 'freeze' much of its unit cost through the capital investment. This need not, however, be seen as exchanging variable (labour) cost for fixed (machine) cost because these concepts become irrelevant: in practice much labour cost has become fixed and different depreciation policies which relate to output

volume rather than simple passage of time make much more sense for the new technologies.

HIGHER EQUIPMENT UTILISATION even when fairly substantial increases in downtime are allowed for technical problems the new manufacturing technologies can still provide dramatic increases in real utilisation through unmanned operation and flexible scheduling.

(e) Failure to Include Soft or Intangible Benefits

Even when all the possible tangible benefits are included in the analysis there are still a lot of extremely important factors which remain unaccounted for:

1. Higher market penetration due to Short Reliable lead times.
2. Schedule dependability due to deterministic scheduling.
3. The learning curve benefits which can only come from adoption of the technology.
4. The volume flexibility in terms of output for the market which is possible through the use of unmanned operation.
5. Labour stability because of volume flexibility with a given labour force.
6. Product flexibility to move quickly as the market changes.

Most of these characteristics are revenue enhancing rather than cost reducing and for this reason are regarded, particularly by accountants, as highly subjective and therefore of dubious value in the analysis. It seems to be much easier to accept the idea of a 10% cost reduction based on a well established and detailed cost statement than the nebulous idea of a market share increase due to better delivery performance. It is obviously difficult to value such benefits but that does not make it correct to assume that they are all zero! The trouble with much traditional 'accounting is that it prefers precision to accuracy, it would rather be precisely wrong than vaguely correct. One useful way of including such factors in the analysis is to establish what the annual return from such soft benefits would need to be in order to reach the required hurdle rate and then ask "is this a feasible value to put on such soft benefits?"

5.2. The Management Communication Gap

The gap in communication between manufacturing engineering and senior management has always been a problem but the new technologies have brought this to a new level of significance. To be fair senior management have been right to be sceptical in the past and their faith has hardly been restored by the failed promises of the benefits from

individual machining centres put into traditional environments. What is needed today is manufacturing engineers with vision and a wide market perspective who are not afraid to raise capital expenditure proposals for figures 10 or even 20 times the corporate norm. On the management side too we need a long term perspective, a commitment to major changes in organisational structure and the will to make it work.

There are usually three clearly identified management groups in many companies faced with the new technologies:

- . SENIOR MANAGEMENT, they know it is necessary to do something for strategic reasons and they are worried about what the foreign competitors are doing.
- . JUNIOR MANUFACTURING ENGINEERS, they (if trained properly) know the technologies and have the expertise but they have little influence and find it difficult to relate to the competitive strategy of the business.
- . MIDDLE MANUFACTURING MANAGEMENT, who, too often, do not know the technologies and feel uncomfortable about them and who in any case are being measured on short term results.

The existence of these three different positions often leads to considerable frustration for both senior management and the manufacturing engineers and considerable stonewalling by manufacturing management.

5.3. Risk Aversion and the Fear of Failure

Most European and particularly most UK managers suffer from a severe form of risk aversion. The reasons for this are complex and cultural but the underlying problem is fear of failure on the part of the individual. In the United States it is readily accepted that if you try lots of innovation some of it will fail but there need be no stigma attached to the individual managers involved in the failure (unless it is clearly caused by incompetence or mismanagement) - it is better to have tried and failed than not to have tried at all. In Japan individuals are perceived to be carrying through a consensus decision so that failure (or success) is shared by all and again no stigma attaches to the individual. In the UK however, two factors seem to govern many aspects of managerial behaviour particularly in manufacturing:

- (a) Most managers see themselves as being in their current job for a very limited time span (2 - 3 years).
- (b) Visible failure in their current position will prevent further progression whereas visible success will guarantee their onward progression in the organisation.

The snag with having these two factors together is obvious - it leads to short term decision making and strong risk aversion.

Of course there will be difficulties with implementing new technologies, of course there will be teething troubles and loss of output and of course

there will be extra costs not known at the start of the projects. However, how many new investments can you think of that have not eventually met most of the initial objectives? Even though individual managers may only be in place for a relatively short period the organisation is intended to continue indefinitely - new technology is a long term commitment.

A manufacturing manager investing substantially in new technology raises his asset base, lowers his return on assets and under current accounting conventions raises his fixed cost - small wonder so few are keen to do it when they are measured on annual performance.

Perhaps the most relevant insight here is a general failure to differentiate between 'sins of commission' and 'sins of omission'. A manager is responsible for a sin of commission if he/she does something which turns out in retrospect to be an error - this is to be expected occasionally if the manager is operating in an innovative way. Sins of commission are therefore unfortunate but should hardly be penalised unless regularly repeated. By comparison a manager is responsible for a sin of omission if something goes wrong as a result of something the manager did not do (but by implication should have done). This is serious and should be strongly penalised in terms of future career progression - it implies that the manager is failing to exert proper custodial control over the business. Applied to the area of new technology investment this idea has much to commend it. It is clearly possible (even inevitable) to commit sins of commission. It is, however, absolutely certain that the do nothing option will in most cases be a serious sin of omission.

6. FROM ISLANDS OF TECHNOLOGY TO CIM

If, as we have discussed, there are considerable barriers to investment in the individual islands of technology there are even more barriers to integrating the islands together to achieve a CIM environment. In justifying a CAD investment, for example, the design office may do this based on such benefits as design productivity, component standardisation etc. In justifying a CNC machine the manufacturing manager may do this on cost reduction, inventory reduction and better quality. Each of these investments may apparently increase productivity in their own area but the real question is whether the business as a whole is actually better off. One useful analogy to illustrate this is to imagine the business as a fluid flowing through a pipe (Figure 3). We started with a 2" diameter pipe and an appropriate flow level. The CAD investment expanded the diameter of the pipe in design to 4", the CAM investment expanded the diameter in component machining to 4" and similarly a new CAPP (MRPII) system was installed which made it possible to double productivity in planning and control - to a 4" pipe. The snag? The CAD interface with the CAM systems still created a bottleneck of a 2" pipe and similarly information availability between the CAM system and production control still restricted flow to a 2" pipe. The result - no real benefit to the business as a whole.

My recurring nightmare of lack of system integration is a designer using a CAD system to produce new drawings (twice as fast as he used to) so that he can fling them 'over the wall' into manufacturing that much faster. When they arrive in manufacturing the manufacturing planning engineer's first task is to feed back into his computer all the necessary data from the drawing in order to use his own CAPE system. This of course prints out operation lists and possibly Bills-of-

Material which he posts to the production control department and tooling and fixture requirements which he posts to the tool drawing office. Production control enter the operations lists into their routing file (for CAPP) and the BOMS into their product structure file. The tool drawing office of course use a different CAD system chosen by the Chief tool designer and so re-enter the detail part co-ordinates before commencing tool design. Meanwhile the CNC programmers are of course preparing from scratch the machine tapes needed for CAM and the plant engineers are similarly transferring the data into the automatic warehousing system which uses customer identification numbers instead of the internal part number.

The dream is of an integrated set of systems each able to operate independently but each able to draw off or supply appropriate interface data at the touch of a button.

There are, however, two very real and very distinct barriers to such integration; one technical and the other behavioural.

6.1. The Technical Problem

I am (I think reliably) informed that - given time, expertise and money - you can in software terms interface anything with anything. In fact despite all the (to me largely incomprehensible) technical problems the basic requirement is quite straightforward. Each island of technology' needs a 'mailboat' package of data to be transferred between islands - the difficulty comes of course in specifying the data package in the first place having transport which is suitable and arranging for a frequency of service which matches the needs of the organisation. The resulting 'integration' more often than not takes the form of Figure 4 with various methods of transfer ranging from the "daily ferry service" through the "DP highwire Act" to the "stepping stones only useable at low tide".

The technical problem is non-trivial and there are any number of cases in which a design office has invested in a particular CAD system in order to improve design productivity only to discover that appropriate post-processors were not always available to enable direct links with CAM.

If the technical problem is daunting the behavioural problem is even worse.

6.2. The Behavioural Problem or "Keep off my Patch"

The behavioural problem is that the integration of the systems described requires a correspondingly integrated approach from management. Design engineers can no longer sit in splendid isolation in the drawing office and fling designs 'over the wall' into manufacturing without regard to available tooling, machine capability or capacity. Design, operation planning, machine choice and capacity planning are strongly interrelated and the "design to production" transfer a continuous (and interactive) process. The key point, however, is that optimisation of the whole process is unlikely to come from optimisation of the individual islands of technology - the individual functional managers cannot be allowed to run their own show as if the other areas did not matter. In practice this

means that there will be limits on system choice placed on the individual areas in order to enable overall integration to be achieved. There are a number of possible ways in which this problem can be tackled and we return to these below.

7. ACTION PLAN FOR MANAGEMENT

It is always dangerous to recommend 'global' action plans but from our discussions a number of clear points do emerge and it is appropriate to summarise these here under a number of headings.

7.1. Major Changes in Financial Evaluation Procedures

- . Realistic hurdle rates (8%)
 - high for fix-its
 - low for long term high-tech
 - premium for 'as-is' technology
- . Include all tangible benefits
- . Allow for intangible benefits:
 - use 'hurdle' annual benefit requirements needed to make investment worthwhile
- . Compare with realistic alternatives assuming competitive action
- . Top down authorisation - abandon ceilings?

7.2 Set-Up Strategic Technology Teams

- . Senior Management
- . Middle Manufacturing Management
- . Technically qualified Manufacturing Engineers
- . Technically qualified Information Technologists
- . Engineering Designers

to address the problem "Given that with no action we will cease to be competitive, what bundle of investments will maximise competitiveness on the following dimensions ..."

To answer such a question the team will clearly also require inputs from marketing and product development.

7.3. Initiate a Major Education and Training Programme

- For
- Senior
 - Middle
 - Supervisory Management
 - Accountants
 - Financial Controllers

-
- In
 - Manufacturing Systems Engineering
 - Technologies
 - Information Processing
 - Financial Justification of High-Tech Investment

7.4 Incorporate Long Term Strategies into Short Term Performance Measures

- . Teething problems
- . Productivity variances
- . Indirect support costs
- . Training costs

7.5. Establish a Specific Technology Input to the Manufacturing Strategy

- . 5 Year Manufacturing technology plan
- . 1,3,5 year implementation plans

7.6 Organisational Structuring

- . Creation of design to production (DTP) teams

This is the major feature of most attempts to overcome the problems of organisational boundaries. Figure 5 illustrates three approaches which have been used:

1. Specialist designers and DTP teams to take the basic design from concept to finished item.
2. DTP teams which are product (or product group) specific but which can call on expert 'staff' help when necessary from consultant designers, manufacturing engineers or part programmers.
- and 3. Totally dedicated DTP teams by product group. This is a form probably most suitable to the larger company with few high volume product lines.

8. CONCLUSION

The challenge of transformation is there but it is necessary to see the new technologies as an opportunity not a threat. Consideration of whether to use the new technologies is no longer the issue. It is not an option but an obligation if the U.K. is to stay competitive in world markets. We are in danger not merely of falling behind in the competitive race but of dropping out of it altogether.

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TABLE 1

NEW TECHNOLOGIES

PAYOFFS TO DATE 1985 SURVEY

	PAYOFF	
	NEGATIVE NONE OR LOW	MODERATE TO HIGH
CAD	46%	54%
CAM	46%	54%
MRP	19%	81%
FMS	67%	33%
ROBOTS	76%	24%



TABLE 2

NEW TECHNOLOGIES

FUTURE EMPHASIS: NEXT 2 YEARS

	NONE TO MODERATE	FAIRLY HIGH OR HIGH
CAD	54%	46%
CAM	54%	46%
MRP	21%	79%
FMS	75%	25%
ROBOTS	85%	15%



TABLE 3

NEW TECHNOLOGIES

GROWTH IN USER BASE

	NO. OF USER PLANTS	NO. OF PLANTS INDICATING FUTURE USE	% INCREASE
CAD	106	167	57%
CAM	102	165	62%
MRP	167	217	30%
FMS	64	115	79%
ROBOTS	69	111	61%

(TOTAL SAMPLE SIZE 240)



TABLE 4

**COMPETITIVE PRIORITIES OF U.K. MANUFACTURING
PLANTS**

RANK

- 1. CONSISTENT QUALITY**
- 2. DEPENDABLE DELIVERY**
- 3. LOW COSTS**
- 4. HIGH PERFORMANCE PRODUCTS**
- 5. AFTER SALES SERVICE**
- 6. FAST DELIVERIES**
- 7. RAPID PRODUCT DESIGN CHANGES**



FIGURE 1 COMPUTER INTEGRATED MANUFACTURING

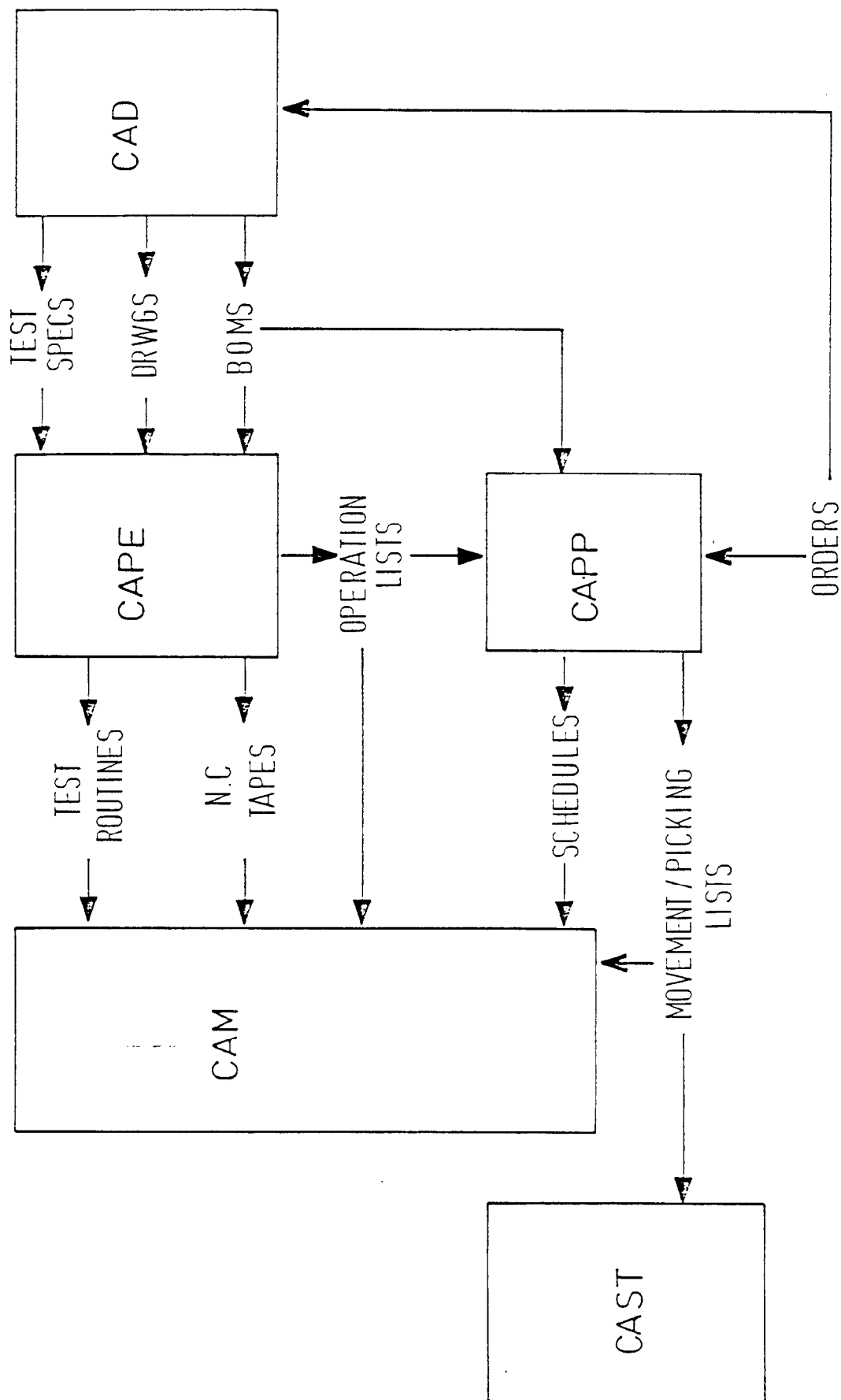
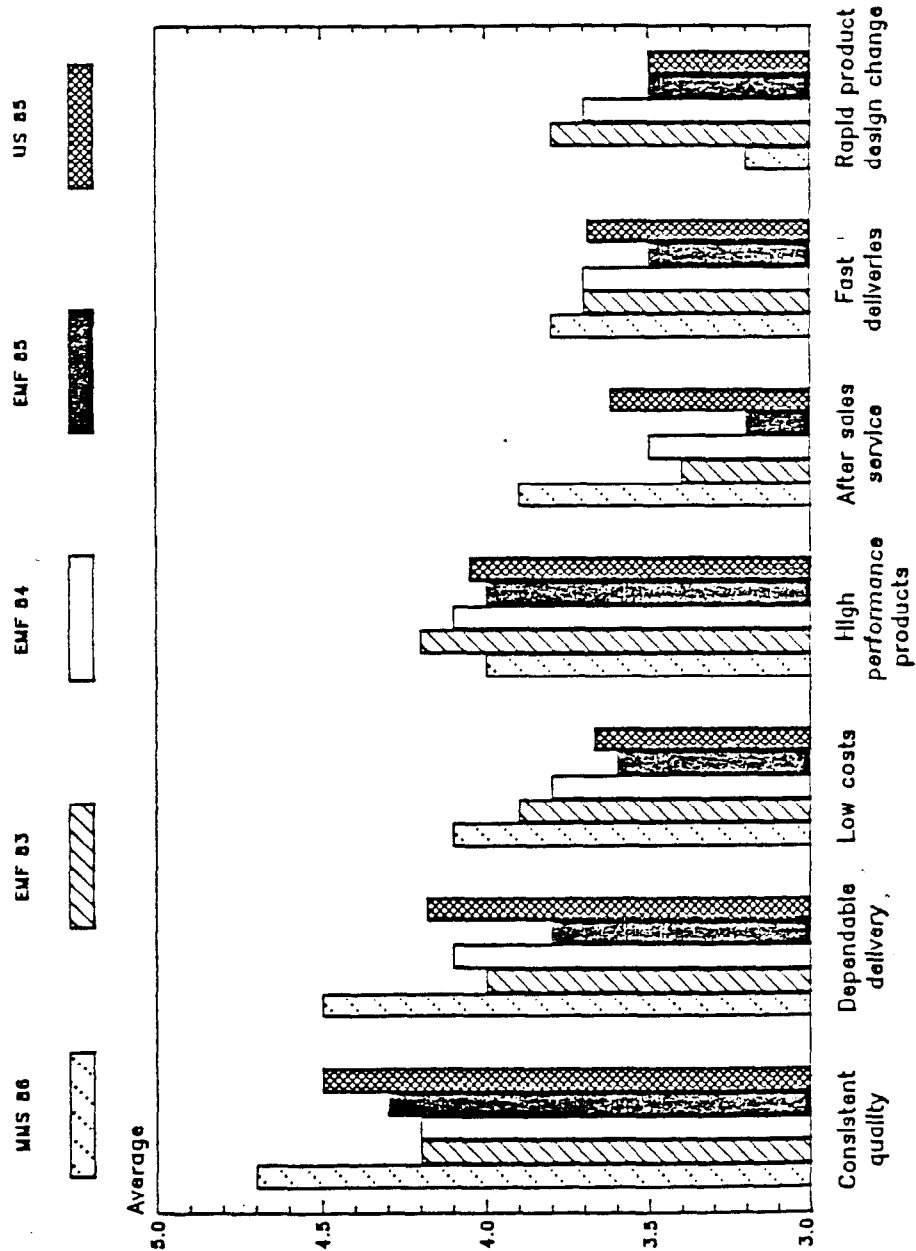


FIGURE 2

COMPETITIVE PRIORITIES

UK v USA v EUROPE COMPARISONS



Competitive Features

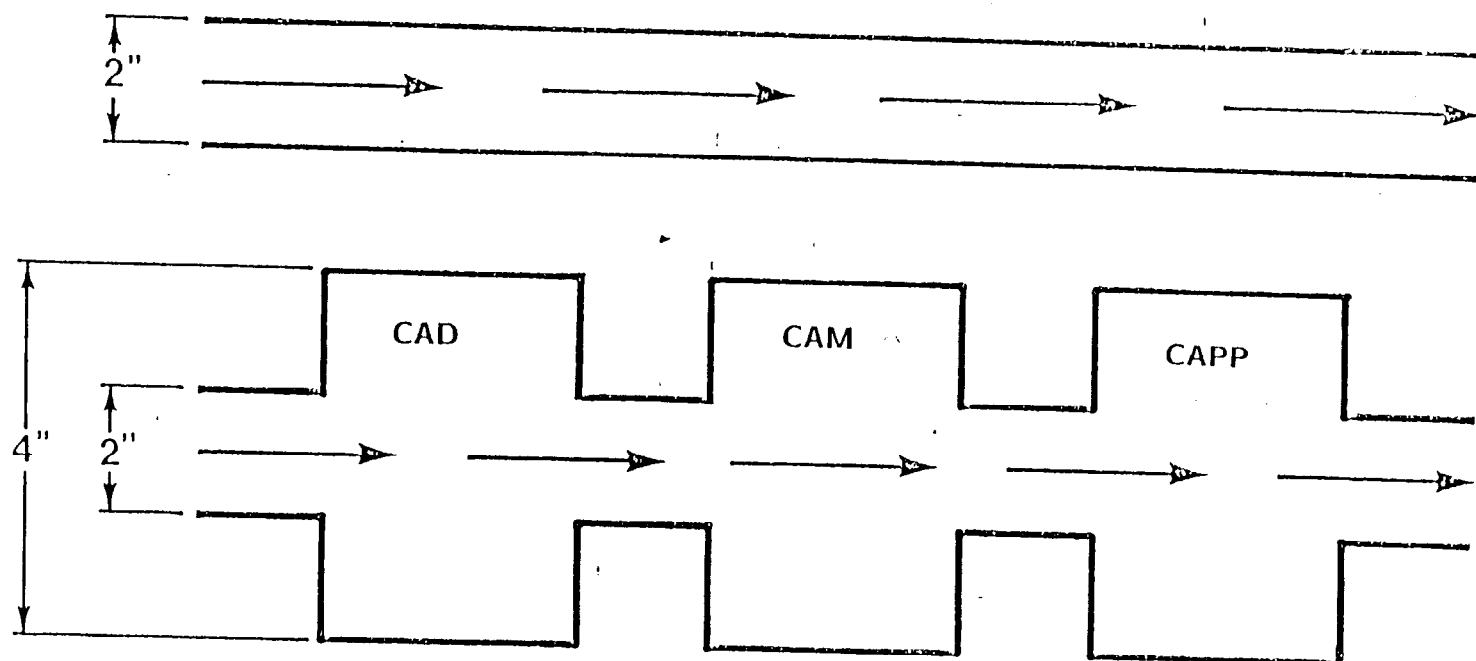
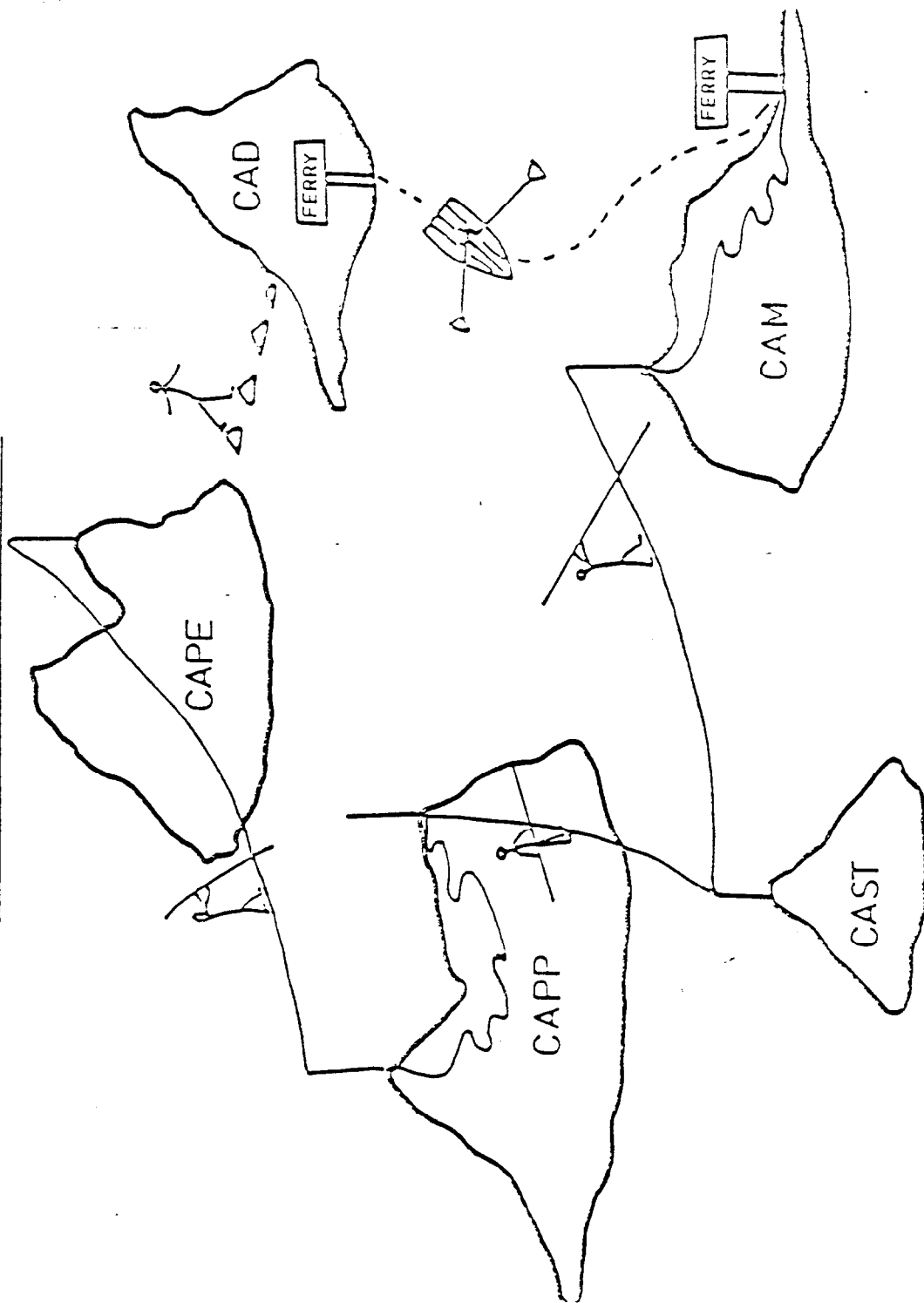


FIGURE 3

Independent Computer Modules Do Not Necessarily Improve Productivity.

FIGURE 4 ISLANDS OF TECHNOLOGY



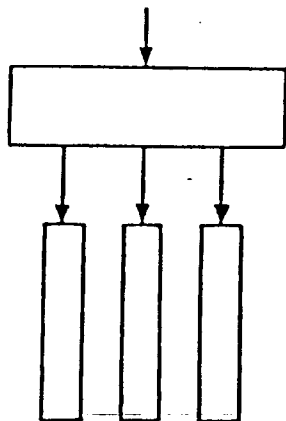
THE 'FIX-IT' SOFTWARE SOLUTION



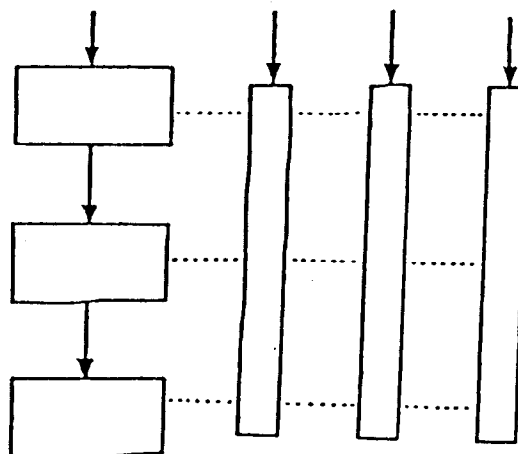
FIGURE 5

ROLE CONVERGENCE UNDER CIM

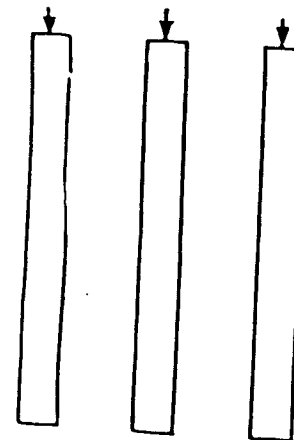
**1. SPECIALIST DESIGNERS
AND DTP TEAMS**



**2. SPECIALIST GROUPS
SUPPORTING
DTP TEAMS**



**3. PARALLEL DTP
TEAMS**



DTP = DESIGN-TO-PRODUCTION