Proceedings of the 1st International Conference on **Simulation in Manufacturing**

Edited by: Prof. W.B. Heginbotham

5-7 March 1985

Stratford-upon-Avon, UK

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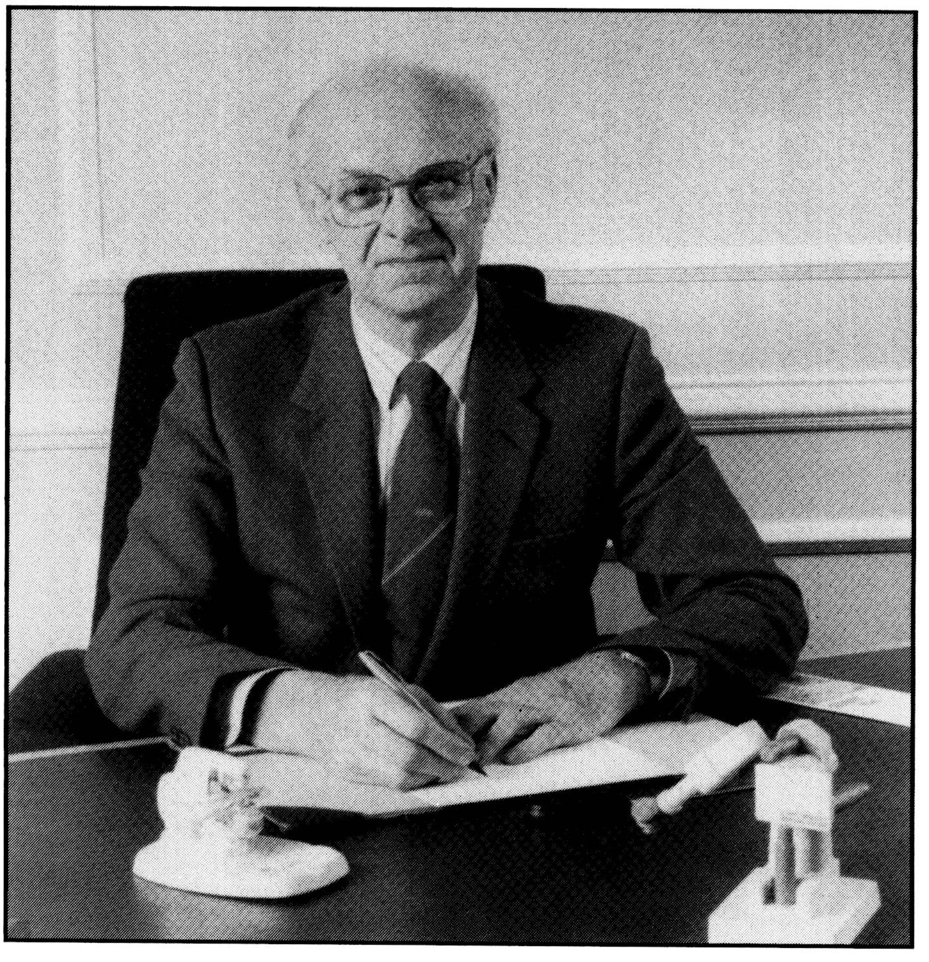
FOREWORD



by Professor W. B. Heginbotham, OBE, DSc
SIM-1 Conference Chairman

SIMULATION started life as a semi-passive tool with a "post mortem" outlook and was looked upon as something of a gimmicky happy hunting ground for the academic. The academic and passive nature of simulation has now been overtaken and complex industrial situations can be represented accurately at an acceptable cost. For instance, interactive graphics simulation can be used to model complete dynamic representations of human activity, multi robot cells with parallel operation, automatic assembly situations, automated warehousing and FMS and including "in process" flow of components and material. This is a precursor to simulation moving into the "driving seat" with "off line" pre-programming of sequences and the inclusion of the effects of "sensory feedback". Further developments, which will incorporate knowledge based systems, will eventually be able to simulate and include the organisational functions like production control, capacity planning and loading and scheduling. So will simulation be a means of total control of manufacturing the like of which is only limited by our willingness to innovate and to apply? This conference points the way for exploitation at this time and indicates what the future holds.

SIMULATION – A MANAGEMENT TOOL

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Late papers

Simulation and reduction of risk in financial decision making

J. F. Wilson
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ABSTRACT

The practice of applying manufacturing technology in a piecemeal way is being replaced by the installation of large, complex flexible manufacturing systems or computer integrated manufacturing systems. These systems represent a major investment for any size of company.

Flexibility is the key to receiving long-lasting benefit from investment in new technology. Flexible manufacturing allows companies to counteract the effects of unpredicable external variables such as changes in the market, availability of skilled staff, supplies of raw material, financial restrictions and competitors activities. This paper defines the risks involved in making financial decisions and describes how the use of simulation models can both quantify and reduce these risks. It also identifies the relationships between the cost and timing of simulation modelling, and relates these to the scale of costs at each stage of a major project, from inception to commissioning.

Introduction

The practice of applying manufacturing technology in a piecemeal way is being replaced by the installation of larger and more complex systems. Market pressures create a sense of urgency about making important investment decisions.

Simulation modelling can offer the key to better systems because it improves the quality of information on which to base decisions, but it can be expensive and time-consuming. So when should simulation be used and what form should it take? To determine that the following questions need to be considered:

- How vulnerable is your business to external forces?
- What is the level of risk involved in manufacturing investment decisions?
- How can simulation reduce these risks? Can simulation techniques be trusted?
- Is simulation good value for money?

Simulation in Perspective

Before discussing these factors in more detail however, it will be useful to compare simulation with other more familiar aids to systems planning.

In planning a complex installation, such as a flexible manufacturing system, a two dimensional-layout will normally be produced. This will show the position of machines, processes, storage, and the type of transportation. It helps explain and visualise the proposed system, but does not demonstrate how it will work. A three-dimensional model does the same thing, but with much greater clarity.

If this model is made to work, then its behaviour can be studied to identify bottlenecks and anomalies. The model can be refined and extended until optimum performance is achieved. Such models have been tried, operated either by moving its elements manually-like a war game - or automatically using small electronic motors under computer control. However, working models are expensive to build, conducting experimental programmes can be difficult, and it takes a long time to obtain results.

Using a computer, it is possible to create an electronic model of the proposed manufacturing system and to study its behaviour:

a) as moving colour graphic displays on a viewing screen, and

b) using print outs of statistics generated during experimental set-ups.

When the model is operational, the scope for experimentation is vast, and results are obtained very quickly.

Simulation is not a technology that stands on its own, it is an integral part of project planning. It comprises:

- Definition of the proposed system installation, including control and scheduling functions.

- Writing and proving of the electronic model.

- An experimental programme accompanied by development of the installation concept and particularly the control and scheduling algorithms.

External Pressures on Manufacturing Industry

If UK companies are to survive, they must face up to international competition. It is no longer good enough to make small incremental changes to improve efficiency. Only aiming to be the best will ensure success and so major investments have to be made. Long-lasting benefits from these major investments will only be obtained if the new system is flexible enough to:

a) adapt to unexpected changes in market demand

b) function in spite of fluctuations in availability of materials

c) be operated by people with various levels of skills

Flexible manufacturing systems (FMS) and computer integrated manufacturing predominate in investment strategies because they provide the flexibility necessary to compete in international markets. (See Figure 1)

These new manufacturing systems generate vital business opportunities and without them many companies will fail. Timing and accuracy in decision making are therefore critical and risks are high.

The high risks in systems installations are:

- Large system installations will radically change and disrupt the company's operations.

- The combination of machines, storage systems, transportation, and the use of computer technologies is unfamiliar to many people.

- System performance depends not only on the performance of its individual elements, which can readily be predicted, but also on the interaction effects between them, which cannot be analysed by conventional manual methods.

In practice, major investments are made as the result of a series of decisions. At any stage, a negative but incorrect decision will deprive a company of an opportunity that may be critical to its survival, while a positive but incorrect decision will waste resources. What is needed is clear and precise information so that decisions can be both accurate and timely. The main decision points in an investment project are shown in Figure 2.

As a project progresses from inception to production each decision point commits a further increment of expense. These escalate with the largest being procurement. Subsequent decisions on production strategy can also be of great financial significance, as they will affect both production output and profitability. Each project step is in preparation for the next and so the expense involved should be reasonable in relation to the cost and risks of the next stage.

Simulation models can be used to obtain advance information on system performance, to refine the layout and size of the elements within the system and to develop control logic during any stage of a project. But the level of detail in the model, and therefore the expense involved, should be reasonable in relation to the degree of risk and level of expense resting on the next decision.

Project Inception

Ideally, projects should be controlled by a top down approach, based first on market requirements, followed by a business plan and then a manufacturing strategy. Much of the data for the justification to proceed with the project concept study will already have been prepared, as part of this company wide study.

Project proposals generated in a more random way by individual champions of new technology, such as suppliers, will require considerably more effort in collection and collation of information to make the case to proceed.

A concept study for a project of £1M may cost £25K - £50K at true costing of resources used and so a decision to proceed cannot be made lightly. It is not usual at this stage to support the decision with detailed analysis or simulation because little basic data will be available.

Larger projects, however, may justify a pre-feasibility investigation. This could usefully be supported by simple low cost simulations based on queueing theory. These models handle average rather than random distribution values of input parameters and so generate approximate information for sizing a proposed system.

Concept Study

The purpose of the concept study is to determine the most suitable system, its cost, the time required to enter production, the systems performance and the risks involved. The main purpose is to quantify these factors so that a decision to implement can be made. The wrong decision could have a major impact on the company's competitive position. Any of a number of inputs of information may be wrong, as illustrated in Figure 3. A valuable project may be rejected or a 'white elephant' may be accepted because of faulty or inadequate information, although the latter may be spotted at the detail project planning stage.

Lack of information can also delay approval and this can have two adverse effects. First, the project may not be completed in time to take advantage of the market opportunity and second, production commitments may have to be met using inefficient methods or by expensive bought out capacity. This is illustrated in Figure 4.

Dynamic simulation models are required during the concept study to determine the best layout, to size system elements accurately , and to establish the flexibility and output of the system in response to different order entry patterns. Its purpose is to determine space requirements and investment costs and to confirm that performance requirements can be met.

It is not necessary at this stage to model the method of transportation within the system, its work scheduling or control logic. It is usually acceptable to rationalise some of the input data to simplify the model thus reducing costs and saving time.

Project Planning

In this phase of a project every detail of the system must be engineered and precisely specified in preparation for procurement and commissioning. The purposes are to ensure that the system will perform as required and to adjust the estimate of project investment cost, if necessary.

Lack of analytical methods to determine the interaction between the elements of a complicated system makes the use of simulation modelling essential. Without it, the performance of the system cannot be predicted with any credibility.

Using simulation during project planning will help to avoid a number of risks, such as:

a) the specification of unnecessary equipment, thereby wasting money and space

b) failure to specify some essential items, leading to extra expense and delay during commissioning, when these faults will have to be specified

c) the need to locate and pay for temporary manufacturing capacity in order to supply customers, or to accept a loss in sales.

These are illustrated in Figure 5.

The greatest risk of all, of course is that the system performs so badly that the investment is wasted and the business opportunity is lost.

At the project planning stage, the dynamic simulation model will include transportation, scheduling, and the control logic of the system. These aspects are needed to explore the operation of the system fully so that it can be specified accurately. The scheduling and control logic handling within the model are particularly significant in reducing software costs and reducing the risk of delays in project commissioning. Advance trials of the logic within the model permit more accurate specification of the systems software. The supplier's task is simplified and the behaviour of the computing system becomes more predictable.

For very large projects, implementation may be carried out in successive phases. The reasons for this approach include:

- Minimising the disruptive effects on the organisation.

- Matching system capability with market demand.

- Balancing the availability of investment monies.

Each phase is in effect a new system and its performance can best be predicted using simulation models which, with forward planning, can be expanded as each phase is added.

<u>Procurement and Commissioning</u>

The relatively long time required to procure, assemble and commission all the various parts of a system, provides the opportunity to prepare for production operation.

Even though the installation may function perfectly it still has to be started up, manned, supervised, maintained and so on. It will also break down at times and contingency plans are therefore needed. The system will have to handle new and varied work, possibly requiring modifications to the system. If people are not suitably trained and procedures planned to cope with all these operational aspects of the system, the required production performance will not be achieved.

The simulation model used to assist project planning can be used, possibly with further refinement, to prepare for production. Experimental programmes can be used to resolve the following:

- The procedure and time required to start up production and to close down to a standard condition ready for restart.

- Behaviour of the system and procedures to be used when parts of the system break down or are withdrawn for maintenance.

Supervisors and managers can use the model to learn about the system before it comes into operation. Subsequently, simulation can be a permanent feature of production. Continually updated with performance statistics monitored during operation, the model can be used to verify advanced loading schedules and evaluate the future effects of proposed production decisions. These may include, for example, modifications of the system and changes in product requirements.

Conclusion

Simulation modelling techniques will substantially reduce the risks in decision-making throughout the course of a project to design and install a large manufacturing system. The level of modelling detail and accuracy, and therefore the cost and duration of the work, should be commensurate with the investment level, business implications and risks involved in each decision to proceed to the next project phase.

References

1. Rathmill, K., "Computer simulation of the factory of the future", Proc. 63rd Infotech State of the Art Conf,. Amsterdam, Oct 1979.

2. Browne, J. and Davies, B.J. "The design and validation of a digital simulation model for job shop control decision - making", Int. J. Prod. Res. 22(2), 1984.

3. De La More, R.F., Manufacturing Systems Economics, Chapter 5, pp 71-93 Holt, Rinehant and Winston, London, 1982.

4. Solberg, J., "Computer models for design and control of flexible manufacturing systems", Proc. 16th Annual meeting and Conf. Numerical Control Soc., Los Angeles, March, 1979.

5. Dupont-Gatelmand, C., "Key success factors for FMS Designs and Implementation", Proc. 2nd Int. Conf., on Flexible Manufacturing Systems, London, October, 1983.

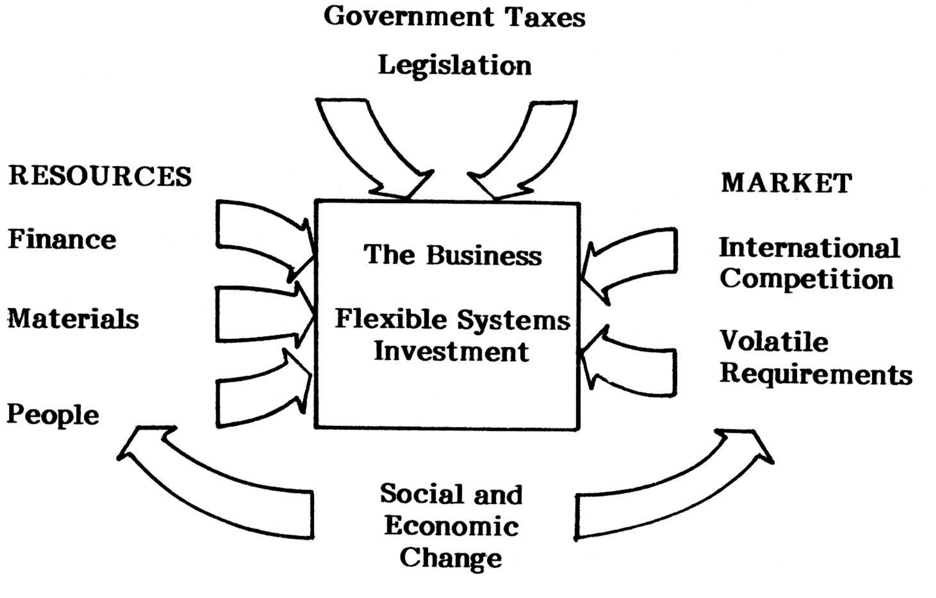


Fig. 1 The External Pressures on a Business Promoting Large Systems Investments

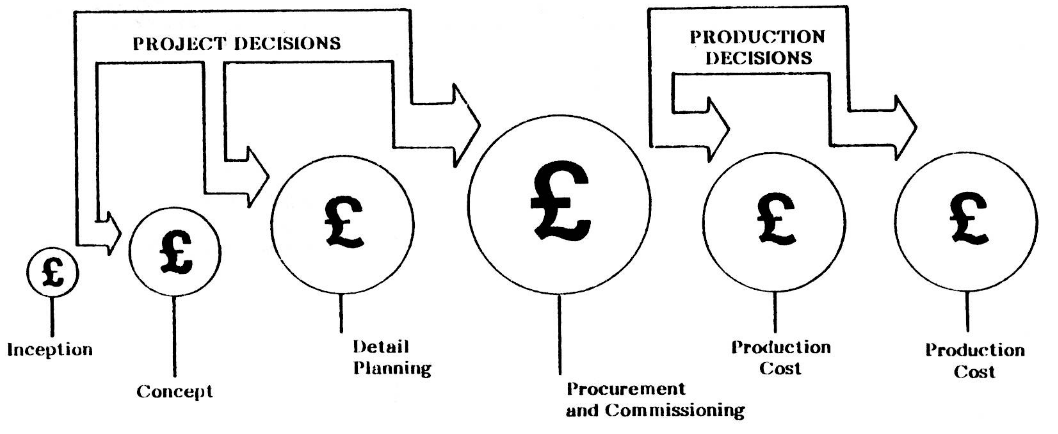
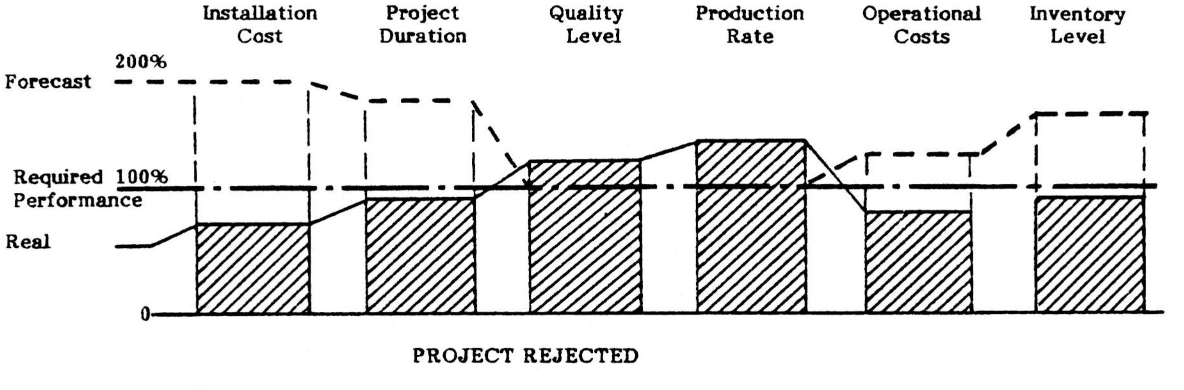


Fig. 2 Project Phasing and Decision Points



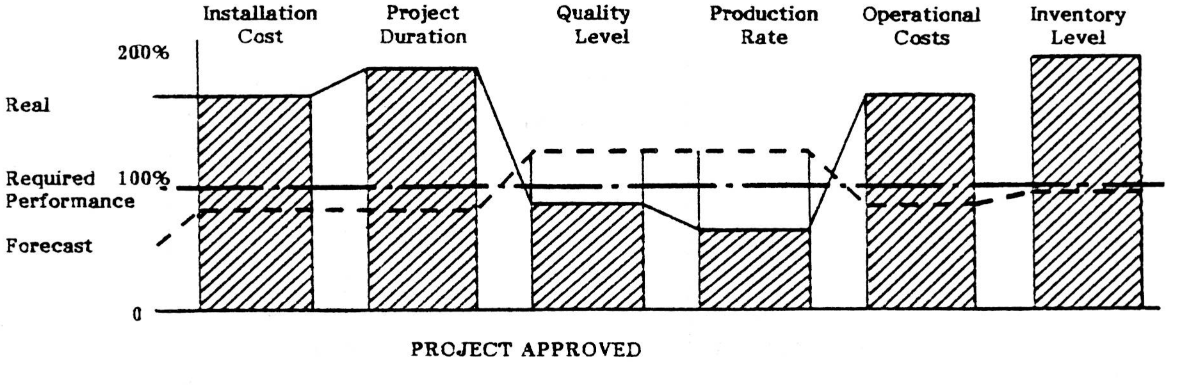


Fig. 3 Project Approval Decisions Adversely Affected by Inaccurate Information

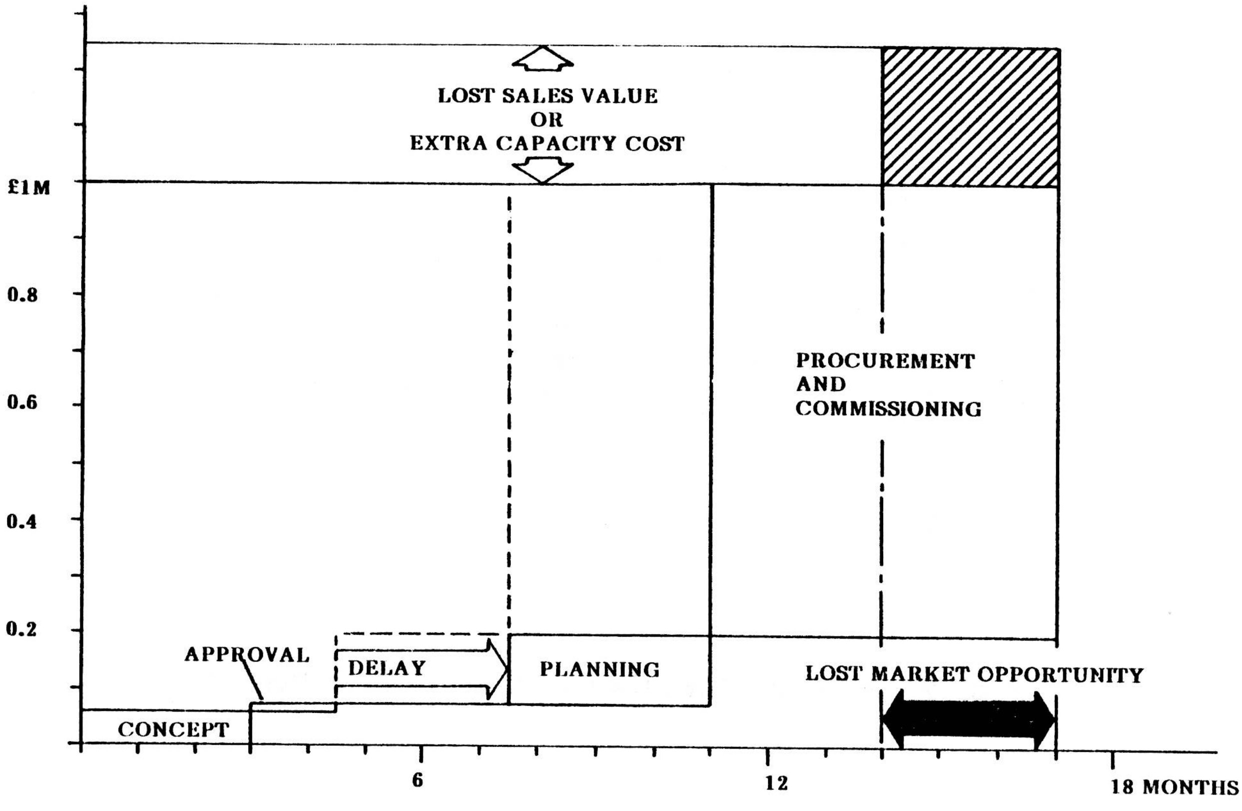


Fig. 4 Effect of Approval Delay on Project

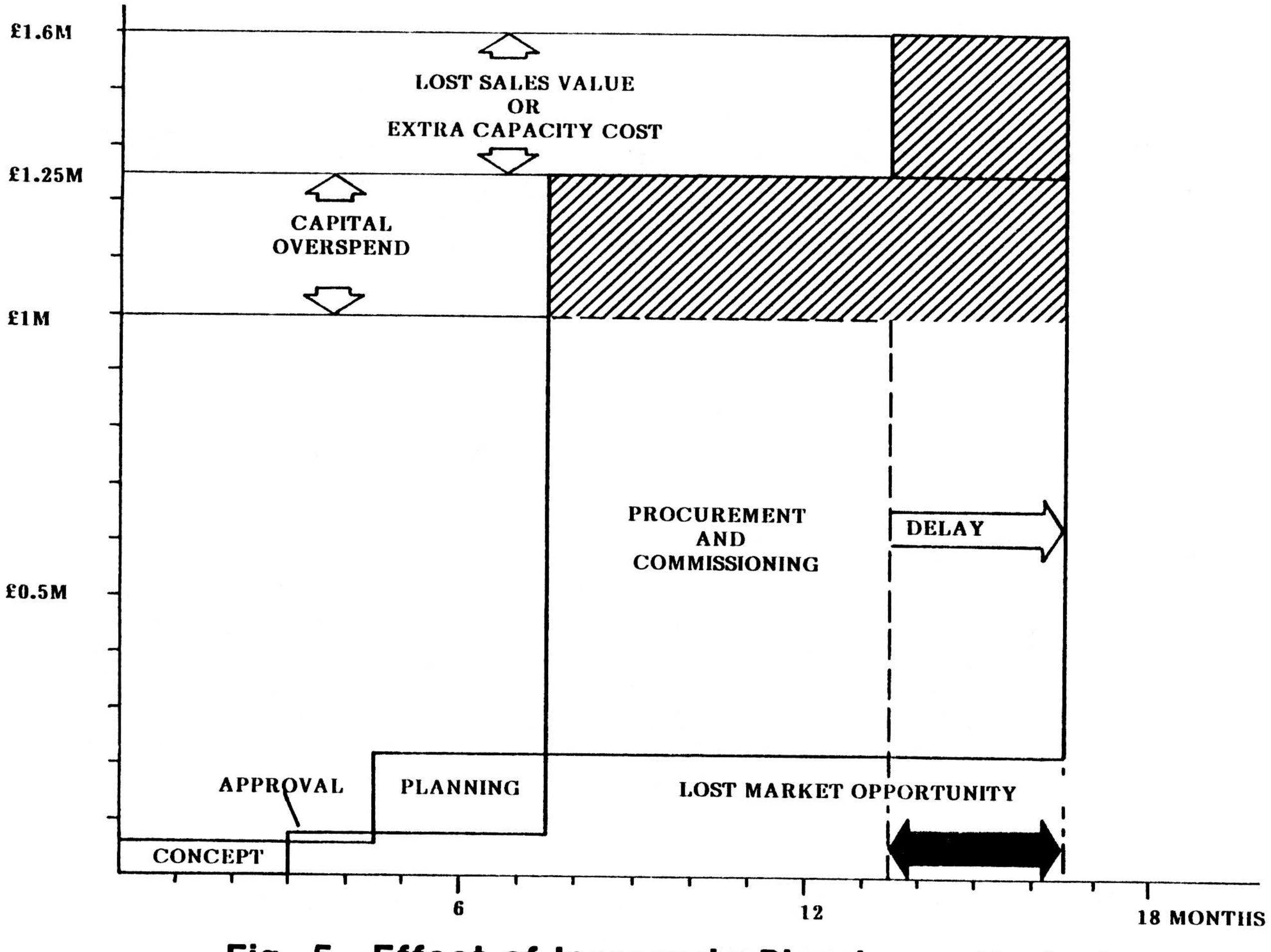


Fig. 5 Effect of Inaccurate Planning on Project

The use of simulation data to determine the optimum economic application of FMS

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and
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SUMMARY

FMS presents a considerable challenge in terms of establishing the most economic configuration but a sound financial appraisal can be carried out if data are available from design simulations. The paper describes how financial evalautions, at both the initial pre-study and the detail design simulation, allow the optimum design configuraiton to be obtained. The techniques developed at UMIST for investment analysis are shown to be readily capable of being interfaced with simulation programs. By mutually interchanging data from financial evaluation and simulation, the data used within both technqiues become progressively more accurate, thereby increasing both the viability of a specific FMS application and the general expansion of FMS.

INTRODUCTION

Early FMS's have often been installed as an act of management faith, with little attempt being made to produce a detailed financial justification. In particular, companies seem to have adopted the attitude that the benefits of FMS are 'intangible' and, therefore, immune to conventional financial evaluations. As a result of this situation, the design objectives of FMS's have been aimed at achieving a range of performance criteria which were not directly related to economic viability other than general targets such as reducing WIP or the number of operators involved. A major research programme is being carried out in the Total Technology Department at UMIST regarding the financial evaluation and justification of Advanced Manufacturing Technology (AMT). This has resulted in the development of techniques which enable the total benefits of a FMS to be financially evaluated, including all 'intangible' benefits. Using these techniques areas can be identified where the maximum savings are generated, hereby highlighting those