A FRAMEWORK FOR THE SELECTION AND IMPLEMENTATION OF PRODUCTION PLANNING AND CONTROL SYSTEMS FOR SMALL MANUFACTURING COMPANIES

BRIAN McGARRIE

A thesis submitted in partial fulfilment of the requirements of Liverpool John Moores University for the degree of Doctor of Philosophy

September 1996

Abstract

This study describes the development and application of a framework to aid small manufacturing companies in the selection, improvement and implementation of production planning and control systems. The framework is developed from the existing literature, which indicates an almost total absence of similar frameworks for small manufacturing companies. The literature was categorised in a Supply Chain Management manner to facilitate close relations between companies when undertaking improvements to the production planning and control system. The framework involves an examination of four phases within a company. The first phase, the Current Reality, enables the company under study to undertake an in-depth audit of their existing production planning and control system. The framework provides focus for the small manufacturing company by identifying problems within the existing system. Problem-solving, via education and training, is an integral part of the framework, with phase two facilitating this by organising and planning for change. The third phase of the framework, the implementation provides the company with a choice of pursuing a software solution to the problems identified in the previous phases, or of simpler, incremental improvements in performance. The final phase, the feedback loop to the Current Reality phase enables companies to follow a programme of continuous improvement. A normal change implementation plan lacks the focus that this framework can provide for the selection and implementation of production planning and control systems. The framework has been validated in ten small manufacturing companies in the U.K., and has enabled one company to successfully select and implement a new computerised production planning and control system. The study reports the application of the framework in this company over a three year period. The advantages of using this framework in action research mode are reported. The other nine case studies highlight the ability of the framework to focus on smaller, incremental improvements in production planning and control performance.

The empirical research also concludes that a lack of human resources to devote to improvements and implementations, is the main difference between large and small companies when undertaking such exercises. Recommendations for future work on the framework are presented, and the usefulness of the framework for managers in small manufacturing companies, consultants and academic researchers is discussed.

Acknowledgements

There are a great many people to thank for their contribution to this thesis.

First of all, Professor Ben Mills of Liverpool John Moores University, for his unstinting support, usually from a distance.

To the great many people who have had the dubious pleasure of me waltz into their office asking detailed questions on MRP. Special thanks to Malcolm and David of the secretive Company A.

In the early days, thanks to Professor Ashok Kochhar, Dr. Keith Oldham, Mike Thacker and Ashok Suri.

Last but certainly not least, to Joanne, for always being there, even 12,000 miles from home!

CONTENTS

Glossary of Terms

AMT	Advanced Manufacturing Technology
APICS	American Production and Inventory Control Society
ATO	Assemble to Order
BOM	Bill of Material
CAD	Computer Aided Design
CAPM	Computer Aided Production Management
CEO	Chief Executive Officer
CIJIT	Computer Integrated Just-In-Time
CIM	Computer Integrated Manufacturing
CNC	Computer Numerical Control
CRP	Capacity Requirements Planning
CSF	Critical Success Factor
DBR	Drum-Buffer-Rope
DNC	Direct Numerical Control
EDI	Electronic Data Interchange
EOQ	Economic Order Quantity
FAS	Final Assembly Scheduling
FMS	Flexible Manufacturing System
GT	Group Technology
JIC	Just-In-Case
JIT	Just-In-Time
MPC	Manufacturing Planning and Control
MPS	Master Production Scheduling
MRP	Material Requirements Planning
MRP II	Manufacturing Resources Planning
MTO	Make To Order
MTS	Make to Stock
NPI	New Product Introduction
OEM	Original Equipment Manufacturer
OPT	Optimized Production Technology
RCCP	Rough Cut Capacity Planning
ROP	Reorder Point
SCM	Supply Chain Management
SME	Small Medium Enterprise
SPC	Statistical Process Control
TOC	Theory of Constraints
TQC	Total Quality Control
TQM	Total Quality Management
WIP	Work In Progress

List of Illustrations

Chapter 1

Introduction

1.1. Background of the Study

The field of production planning and control has undergone tremendous change in the last 30 years. Prior to the 1960's, inventory was controlled by a manual system, according to Ptak [1], who further explains that it utilized various techniques: stock replenishment, reorder points (circa 1934), EOQ (economic order quantity, circa 1915), and ABC classifications, to name a few.

Gilbert and Schonberger, [2], provide a good history of production control, and Lee [3] comments that by the mid-1970s, enough experience of Material Requirements Planning (MRP) had been gained and the importance of the Master Production Schedule (MPS) was realized.

It was soon recognized that material availability was not the only problem that could affect a manufacturing schedule, and Millard [4], discusses that if, for instance, material was available but labour, tooling or machines were not, the manufacturing plan would still be in jeopardy. It was this difficulty that led to the realization that MRP was not enough to control manufacturing. This same author describes the development of feedback type of control systems that would detect plans that were either underscheduling or overscheduling manufacturing resources, whereby this became known as closed loop MRP, with the feedback loop providing a means for comparing a manufacturing department's workload to its capacity, and in some versions, suggesting corrective action. Thus, closed loop MRP is MRP plus a capacity planning capability.

Millard further explains that the term closed loop MRP is generally accepted to be concerned with labour and material planning at the master production scheduling level, and that MRP II is an extension of closed loop MRP that provides the capability to express manufacturing plans in terms of pounds sterling. In other words, MRP II provides a financial dimension in a similar manner that closed loop MRP provides a labour and equipment dimension.

Hannah [5] highlights a parallel development happening in Japan, where the oil crisis of 1973 created a severe decline in profitability for Japanese manufacturers, who sought to offset this threat with a new method of improving labour productivity without excessive capital investment. Hannah then describes the Just-In-Time (JIT) system which was developed by Toyota to respond to this need.

According to Sewell [6], the emergence of Japan as the world's strongest economy combined with the shift eastwards in the centre of gravity of industrial power in key sectors like motor vehicles, microelectronics, machine tools and electrical consumer goods must rank as one of the key economic phenomena of the last decade.

Kochhar and McGarrie [7] reveal that since the late 1960's, in spite of the expenditure of large amounts of time, money and effort, manufacturing companies all over the world, have struggled to implement truly effective computer-based manufacturing control systems, and, that it is often the case that many implementations are undertaken without a detailed consideration of all the related factors.

Newman and Sridharan [8], argue that historically the selection of MPC systems has been influenced more by the latest system developments, internal knowledge and information processing constraints of the firm than by environmental factors faced by the firm.

These authors' believe that production volume and product variety are the key factors in describing the environment, and that it is somewhat unclear and as yet undefined in the literature as to how the manufacturing planning and control system should be selected for a specific manufacturing environment.

Many firms make large investments in processes and manufacturing infrastructure, such as control systems, without an adequate understanding of their markets, according to Berry and Hill [9]. These authors' also explain that to meet corporate expectations and CEOs' demands, manufacturing has, in the past, resorted to investing in a series of panaceas and control (MPC) systems.

Krupp [10] proposes that just as a corporation maintains a portfolio of marketing strategies, with each product type assigned a strategy appropriate to its marketplace, so should a portfolio of planning systems with each unique operating environment evaluated to determine the most appropriate planning/control system. Krupp therefore concludes that creativity in both designing and enhancing MRP systems is crucial to ensuring the best fit between system and environment.

The definite need for research on successful MRP implementation by small manufacturers is suggested by Blackstone and Cox [11], who argue that the concepts which worked for large manufacturers, especially larger implementation teams, may not be appropriate or may have to be modified for small users. Torkzadeh and Sharma [12] argue along similar lines that there is extensive literature on the experiences of large and mid-size firms with MRP, but not much literature related to small companies.

The existing literature on JIT in small manufacturing companies is relatively sparse according to Brown and Inman [13].

The same theme is further developed by St. John and Heriot [14] who highlight the fact that most of the current published material focuses on the implications of JIT for the manufacturer that implements the system, with a notable omission being the impact of JIT manufacturing on the purchasing relationship that exists between JIT manufacturers and their small business suppliers.

The changing business environment is addressed by Herroelen and Lambrecht [15] who argue that marketing pressures completely changed the competitive manufacturing environment during the first half of the eighties, leading to a clear trend of rapid obsolescence of products, with product life cycles being shortened considerably. Consequently, the primary operational sources of advantage in today's competitive environment will be; quality, reliable delivery, shorter lead times, customer service, rapid product introduction, flexible capacity and efficient capital deployment.

These authors' believe that this environment requires a different manufacturing system which can respond promptly to reconcile all manufacturing activities quickly, and that one of the most affordable and practical alternatives is to innovate the current production system in order to enhance productivity and competitiveness.

Gardner [16] also believes that rare is the case where an entire system should be abandoned in favour of a better one, so retaining effective portions and adding improvements as called for is certainly preferable to throwing out the 'baby with the bath water'. This same author suggests that one reason for system implementation failure is the failure to realize the importance of retaining and improving the existing production planning and control system. The importance of MRP Re-implementation was highlighted by Krupp [17].

Saunders [18] believes that the choices of planning and control systems should take into account not only the needs of particular subfunctions, but also the potential for integrated planning and control of the supply chain as a whole and the interfaces with the other functions not directly involved.

The need to involve suppliers in the choice of system would appear to be reinforced by the estimate of Willis and Huston [19], that roughly one-half of manufacturing costs are attributable to purchased items, and raw materials account for 80 per cent of a finished product's lead time and 30 per cent of its quality problems. However, this is based on an assemble-only environment, which would be expected to have a high purchasing cost.

1.2 Objectives of the Study

The lack of empirical support for the selection and implementation of production planning and control systems in small manufacturing companies gives rise to the following pertinent questions;

i) Can a framework be provided to aid small manufacturing companies in successfully implementing production planning and control systems?

ii) Can lessons be learned from both suppliers and customers when selecting and implementing new production planning and control systems?

iii) Are there major differences between small and large companies when it comes to implementing production planning and control systems?

iv) Can action research allow the framework to be developed?

v) Can incremental improvements lead to a satisfying outcome for smaller manufacturing companies?

The objective of the study is to try and provide answers to these questions.

1.3 Definition of Key Concepts

Prior to commencement of the study, some of the key concepts that are used here need to be defined. These definitions are advanced below.

Reorder Point (ROP) is a simple system whereby any regularly used material is re-ordered when the inventory drops to a certain level, according to Richman and Zachary [20]. These authors highlight the fact that the appropriate level is usually a function of:

> " how long it will take for the new order to arrive (lead-time);
> how much material is likely to be used up in-house before that time; and
> how much of a cushion (safety stock or buffer inventory) the materials manager feels must be maintained to minimize the probability of running out while not tying up too large an amount of money in materials sitting on a shelf."

Order point and time-phased MRP are diametrically opposed to each other, reports Brenizer [21]. This author describes order points as representing demand with component usage history data, and as a pull method whereby inventory is generated to cover (in theory) expected end-product orders that bear little relationship to time of production or delivery. He also stresses that planning is performed bottom-up as opposed to MRP where planning begins top down.

An important distinction between order point systems and MRP, according to Orlicky, Plossl and Wight [22], lies in the fact that the order point/order quantity approach is part based whereas MRP is product oriented. Consequently, order point views each inventory item independently of all the others, whereas MRP looks at the product and the relationships of its components, using bills of material as the basis for planning.

Ptak [1] defines MRP (materials requirements planning) as:

> " .. a logical planning system that nets gross requirements for dependent demand. It explodes through bills of materials from top-level independent demand and nets against current on-hand and on-order balances. It attempts to drive inventory to zero by providing materials to manufacturing precisely when they are needed. In short, MRP provides the planning logic necessary to make or buy only that what we need when we need it. "

The American Production and Inventory Control Society (APICS) define MRP II:

> " A method for the effective planning of all the resources of the manufacturing company. Ideally it addresses operational planning in units, financial planning in pounds, and has a simulation capability to answer 'what if' questions. It is made up of a variety of functions, each linked together: business planning, production planning, capacity requirements planning and the execution system for capacity and priority. Outputs from these systems would be integrated with financial reports, such as the business plan, purchase commitment report, shipping budget, inventory projection etc.". Wallace and Dougherty [23].

APICS also produce the standard definition of the Master Production Schedule (MPS):

> " For selected items, it is a statement of what the company expects to manufacture. It is the anticipated build schedule for those selected items assigned to the master schedule. The master scheduler maintains this schedule, and, in turn, it becomes a set of planning numbers which "drives" MRP. It represents what the company plans to produce expressed in specific configurations, quantities, and dates. The MPS should not be confused with a sales forecast which represents a statement of demand. The master production schedule must take forecast plus other important considerations (backlog, management policy, and goals etc.) into account prior to determining the best manufacturing strategy." Wallace and Dougherty [23].

Ware and Fogarty [24] go further, and define a master schedule as synonymous with the master production schedule. These authors believe that the master production schedule should include only a time-phased build plan, which is a statement of what the company expects to manufacture, whereas the master schedule will contain all three types of information, namely:

> " ...creation information used to build the master production schedule, namely the requirements and the projected on-hand; the master production schedule itself; management information used to control order acceptance and order promising, namely the available to promise"

Ling and Sari [25], highlight the difference between Final Assembly Scheduling (FAS) and MPS, namely that MPS is the anticipated build schedule, whereby, FAS specifies the actual build schedule covering a period that begins when all the component items are available for final assembly and ends when the products are shipped to customers. These authors also suggest that Rough Cut Capacity Planning (RCCP) actually involves an analysis of the MPS to determine the existence of critical manufacturing facilities that are potential bottlenecks in the flow of production.

Maes and van Wassenhove [26] describe the development of OPT (Optimised Production Technology) as probably the best known example of Bottleneck Scheduling Systems, and gaining notoriety through the quite aggressive marketing strategy of its creators. They go on to describe its' promotion, at first, as a software package for short-term production control based on finite loading, and its' subsequent evolution to a more complete production philosophy in which bottleneck management and buffer control are 2 core elements, the so-called Theory of Constraints (TOC).

The Theory of Constraints (TOC) has spawned a scheduling technique, drum-buffer-rope (DBR), and a control mechanism, buffer management, which have been defined by Gardiner, Blackstone and Gardiner [27]:

> " ..provides a framework that distills the complexities of material flow into an understandable format; reduces drastically the number of resources that must be explicitly scheduled; warns of potential disruption to the production plan; controls lead time; guides continuous improvement efforts; offers a significantly improved alternative to the kanban production system; aligns local resource performance measures with global organizational performance; makes traditional job shop capacity management techniques obsolete."

Fawcett and Pearson [28] further describe Constraint Management as attempts to achieve synchronization by improving management of constraint resources and then scheduling all operations off these critical resources, with a basic premise that companies exist to sell their products for a profit and that constraint management can help a company achieve this goal by improving the company's competitive position through the better scheduling and utilization of all its productive resources.

Many definitions have been put forward for Just in Time manufacturing (JIT) and they are being continuously updated as JIT is being more globally accepted. Goyal and Deshmukh [29] provide a literature classification of papers/articles on JIT definitions and objectives and JIT as a philosophy.

They conclude that many of the contemporary definitions focus on JIT as an approach to minimize waste in manufacturing, or more generally aiming at zero inventory, and at this stage it may be difficult to put forward an all-encompassing definition, with JIT being viewed as a philosophy cutting across all the functional departments.

Bartezzaghi and Turco [30] conclude that the most frequent attributed meanings of JIΓ are two: the first considers JIT as a global approach to production system management, in an innovative key; the second identifies JIT as a set of techniques, synergistically addressed at the implementation and continuous improvement of the production system.

Zipkin [31], in a similar vain, suggests that there are two very distinct messages in the JIT literature; on the one hand, advocates describe JIT merely as practical insights to the practical problems of factory management; on the other hand, they depict JIT as a radically new philosophy, even a culture. Zipkin calls these two perspective pragmatic JIT and romantic JIT.

Cheng [32] believes JIT to be much more than just a manufacturing technique. Instead, it is a broad-based manufacturing philosophy, embracing a body of management principles and an array of management systems and techniques, which will, if used correctly in the right manufacturing environment, greatly increase a firm's productivity and enhance its competitiveness in the marketplace. Cheng focuses on three elements as the building blocks of the foundation on which a successful JIT system rests; waste elimination, introducing workplace organization and fostering total employee involvement. Similarly, Pegler and Kochhar [33] argue that JIT is not a simple off-the-shelf solution to all manufacturing problems, rather it is a production philosophy covering most if not all aspects of a manufacturing operation.

JIT may be also viewed as a production methodology, according to Voss and Robinson [34], which aims to improve overall productivity through the elimination of waste and which leads to improved quality, providing for the cost-effective production and delivery of only the necessary quality parts, in the right quantity, at the right time and place, while using a minimum of facilities, equipment, materials and human resources.

Heiko [35] presents a simplified conceptual framework for JIT consisting of one objective and four implementing principles. The one objective is the design and management of a production system to minimize production lead time, which is defined by Heiko as the total elapsed time from the arrival of incoming material from supplier, through its transformation in the production process, to its delivery as outgoing material to customers.

To describe Just-In-Case (JIT) and JIT as philosophies or regimes is misleading as it implies an internal coherence which does not necessarily exist in reality, according to Oliver [36], and they are best viewed as ideal types rather than distinct packages which are always found in practice. Oliver believes that this is particularly the case with JIC which is not so much a coherent strategy as traditional Western custom-and-practice.

Much attention has been given to JIT manufacturing under the name of the Kanban-controlled pull system, which differs from the conventional push system, and Singh and Brar [37] compare both using the transmittal of information to distinguish one from the other. That is, in a push system, information is transmitted in the same direction as the part: jobs entering are queued at the first process and scheduled for further processes until they leave the system in the same order as they are fed into the first process. On the other hand, in a pull system, parts move in the same direction as the push system, but the information concerning the processing of that part is given by the subsequent process.

The same authors define kanban as a card attached to standard containers which issues the production and withdrawal of parts between work stations. Consequently, it is usually viewed as an information system that controls production.

Wemmerlov and Hyer [38] describe Cellular Manufacturing (CM) as one specific application of GT, involving the processing of collections of similar parts (part families) on dedicated clusters of dissimilar machines or manufacturing processes (cells).

Kamenetzky [39] distinguishes between planning functions and execution functions, with the main planning functions being MPS, MRP, the main outputs being a series of time phased manufactured and purchase orders. These outputs feed into execution modules of inventory control, production control and purchasing. Kamenetzky also defines scheduling and sequencing. According to this author, the term scheduling is used to refer to the setting of operation dates and delivery dates for manufacturing orders (or jobs or lots), whereas the term sequencing is used to refer to decisions concerning the sequence in which manufacturing orders will be processed at a given production centre.

The APICS Small Manufacturing Special Interest Group defines a small manufacturer as a goods-producing company with annual sales less than 25 million dollars and with less than 100 employees [40]. On the other hand, Cooke [41] broadly defines the small/medium company sector as companies with less than 500 employees or with a turnover of less than £25 million. Brown and Inman [13] also stress that the distinction between large and small manufacturing firms may be defined as the number of employees with a small firm employing fewer than 500. The European Union definition also views a small-medium enterprise as a distinct business entity with not more than 500 employees [42]. The same authors also note that size is relative to sector. This European Union definition can be decomposed.

The Cambridge Small Business Research Centre [43], define a further four categories:

"Micro: less than 10 employees.
Small: 10-99 employees.
Medium: 100-199 employees.
Larger: 200-499 employees".

For the purpose of this study, the decomposition by The Cambridge Small Business Research Centre will be used to define and clarify the small company research to be undertaken.

1.4 Structure of the Study

1) A comprehensive review of the theoretical literature on production planning and control systems, to identify existing approaches to the selection, implementation and improvement of production planning and control systems. (chapter 2)

2) A comprehensive review of the theoretical literature on production planning and control systems, to identify the characteristics affecting the selection, implementation and improvement of production planning and control systems. (chapter 3)

3) Development of a framework, based on the literature, which captures the relationship between supply chains and the selection, implementation and improvements of production planning and control systems. (chapter 4)

4) Determining the methodology for data collection to test the framework. (chapter 5)

5) Review of the empirical findings of the usefulness of the model in selecting and implementing a new production planning and control system for the test sites. (chapter

6) A discussion of the results obtained in the test sites. (chapter 7)

7) A review of the conclusions emerging from the use of the framework in a number of test sites. (chapter 8)

8) Implications of the study and suggestions for further work.(chapter 8)

Chapter 2

Literature Review

2.1. Introduction

A review of the existing literature reveals that very little attention has been given to fully tested models and frameworks for the selection and implementation of production planning and control systems.

Much of the literature is devoted to the implementation of one particular type of planning and control system. Therefore, the results of this literature review can be categorised into three groups:

i) Papers/articles that consider a number of different types of production planning and control systems.

ii) Papers/articles that consider a combination or hybrid of two different types of production planning and control system.

iii) Papers/articles that consider only one type of production planning and control system.

For each of these three categories, the literature is further decomposed into those considering case studies, surveys and conceptual studies.

Appendix 1 provides a complete overview of all the papers reviewed in this chapter (arranged alphabetically).

The objective of this chapter is therefore to review the different approaches taken by authors to select, implement and improve production planning and control systems.

The identification of individual characteristics affecting the selection, implementation and improvement of production planning and control systems will be undertaken in chapter 3.

2.2 Literature Categories

2.2.1. Papers/articles considering a number of different types of Production Planning and Control Systems

a) Case Study-based Research

The definitive study of Computer-Aided Production Management (CAPM) in the U.K. batch manufacturing industry is provided by Waterlow and Monniot [44] who investigate 33 manufacturing units and 5 suppliers of CAPM systems. This study demonstrates that the prerequisites for successful CAPM implementation, change as the extent of CAPM system integration increases, and that organisational rather than implementation issues dominate as integration increases.

Kochhar and McGarrie [7] identify a number of key characteristics for the selection and implementation of production planning and control systems, emerging from seven case studies of UK discrete batch manufacturing industry. These characteristics can be categorised into those taking account of external considerations and those taking into account internal considerations.

When the authors examine the key points under the categories of market demand, products, manufacturing processes, systems and the organisation, it can be seen that some of the key points result in a complexity of the manufacturing systems and hence affect the need, choice and implementation of different manufacturing control systems. This complexity creates uncertainty and inhibits implementation. However, some characteristics actually created flexibility and consequently helped overcome some of the problems created by the complexity and uncertainty.

The authors conclude that it is possible to develop a structured framework around the characteristics of complexity, uncertainty, flexibility and likelihood of success. Management can then take the appropriate action to minimise the effect of factors likely to inhibit the implementation of the selected manufacturing control system. The companies studied were of medium to larger sized operations, and thus no conclusions could be arrived at regarding the importance of these characteristics in small manufacturing concerns.

The selection of CAPM is also dealt with by Maull and Childe [45], who outline the results of the a research team engaged in developing a CAPM implementation methodology for the electronics sector. The research team believe that the results are widely applicable to CAPM implementation in other manufacturing sectors. They suggest that any approach that aims to identify a CAPM solution must deal with 3 key elements: the complexity of the manufacturing system must be attenuated; software specification must be considered, and a balance between infrastructure and software must be achieved. The authors' develop a step by step approach to the identification of a CAPM solution. A user-led approach is outlined, and the methodology is developed fully in the CAPM workbook, including the CAPM task model which provides a step by step guide to the specification and selection of a CAPM system most appropriate to the needs of an individual company. However, no case studies are actually provided but reference is made to a number of electronics companies.

Bessant and Buckingham [46] construct a possible hypothesis to account for the high level of implementation failure in CAPM, namely, that organizations are being required to learn, to respond through the development of new structures, processes, skills, and cultures, in order to obtain the full potential benefits offered by the technology. The authors' argue that the extent of the challenge posed by such radical technology requires not only adaptive/tactical learning but also generative/strategic learning. The authors provide a detailed analysis of success and failure factors. However, the research is only applied to three case studies, all employing over 200 people.

Berry and Hill [9] explore the design of MPC systems which fit the business, by linking markets, processes and systems. These authors provide frameworks for linking manufacturing strategy to the design of the MPS, shopfloor control systems and material planning approach. Four case studies are presented in this paper, but no small manufacturing companies are considered.

b) Survey-based Research

In a survey of production planning and control practice in the U.K., Little [47], reveals that few respondents report the use of predominantly JIT-based systems. Of 311 responses, over 95% of respondents had more than 50 employees and 18% have over 1000. There is no doubt, according to the author, that MRP/MRP II systems are mature and are producing significant benefits for a wide range of companies. However, it is hard to gauge from the survey, the practice of production and control in small manufacturing companies.

Newman and Sridharan [8] surveyed 185 manufacturing firms in Ohio, from a wide spectrum of industry including machine tools, automobile components, furniture, plastics, medical equipment, computers, defence electronics. A majority of firms (56%) reported using MRP-based systems, followed by ROP 22%, kanban 8%, OPT 5%. The remaining 9% reported 'home-grown' systems created to meet their unique needs. These authors suggest that ROP users appear to have the best performance overall, and that this counteracts the contemporary literature. This survey also shows that ROP is used predominantly by smaller firms, and is the oldest MPC system in use, with an average age of implementation greater than 20 years. According to the author's, the increased information-processing requirements entailed by MRP may prove a hindrance to firms that do not need such a complex system, where variety is low and demand steady. The results from this survey have potential use for aiding the selection and implementation of production planning and control systems for small manufacturing companies.

However, there is again a lack of detail surrounding the number and type of small manufacturing companies covered by the survey.

Barber and Hollier [48], classify companies according to production control complexity within the engineering batch manufacturing sector in the U.K. They undertake their classification process by means of a cluster analysis of 88 responses to their questionnaire. No information is given regards the number and type of small manufacturing companies considered within their research.

c) Conceptual Research

A framework is developed by Grunwald, Striekwold and Weeda [49] to compare various concepts in production control, namely Statistical Inventory Control, MRP II with safety stock and overplanning, JIT and OPT. In this model, 3 factors are used to categorise the model; market, production technology and production organisation. No testing and validation of the framework is undertaken, although future simulation experiments are planned.

A four stage Executive Guide to Manufacturing Control Systems Selection, is proposed by the Institute of Production Engineers [50]. The 4 stages recommended are; defining the strategic requirements of the company, specifying the functional requirements of the system, selection of the package, and negotiating the contract. No examples of company cases, and no description of the potential differences between large and small company implementations, are provided.

Five basic principles of production control are suggested by Luscombe [51]. The author argues that these principles are fundamental to the success of any production control system. The relationship of the three most popular production control systems, MRP II, OPT and kanban, to the five principles is explored. The five principles are: there must be an agreed production plan; there must be a fast effective way of managing change; control the scheduling system not the schedule; there is no production without capacity; data must be accurate and accessible.

The CIM Institute at Cranfield has developed a complete methodology for the design and implementation of production control systems, based upon the these principles, although no results are presented.

The production planning philosophies of MRP, JIT, OPT and DPP are compared by Larsen and Alting [52], and the main characteristics of each are provided as criteria for selecting a production control philosophy. However, these characteristics have not been applied within industry.

Maes and Van Wassenhove [26] consider MRP, JIT and bottleneck scheduling, discussing the functionalities required by each, and propose the core characteristics of a hybrid system. Again, the core characteristics are not tested and validated.

The inherent compatibility of microcomputer-based MPC systems with small manufacturing is addressed by Marucheck and Peterson [40]. Despite the usefulness of the concepts, the work remains untested in small manufacturing companies.

The development of a conceptual world manufacturing information flow model is considered by Plenert [53]. He argues that the control and feedback mechanisms of the MRP based information flow diagram have become impressively complex. The model is developed for the management of each of the 3 major resources of an organization; labour, materials and machinery/facilities. The models developed by Plenert provide useful information flows for a number of production planning and control systems but lack the robustness that comes with full testing in a range of company environments.

Ptak [1] argues that OPT is a bridge between MRP, MRP II and JIT, and that it utilizes areas from each while providing a focus for process improvements on the bottleneck resource.

This author suggests a company must draw from the entire gamut to extract what makes sense for that particular company, but provides no evidence of the application of the control systems in a combined mode.

2.2.2. Papers/articles considering a Combination/Hybrid of two types of Production Planning and Control System

a) Case Study-based Research

In an in-depth investigations of 8 carefully chosen manufacturing organisations in the U.K., Burcher [54] concludes that the most significant area where practice did not seem to be following MPS theory, was the lack of use of detailed Capacity Requirements Planning (CRP) and the lack of closing of the loop by feeding back from this check to the MPS process. To follow up on this research, Burcher surveyed 349 companies.

The overall findings of this research suggest that at the critical interface between the market place and production, namely the MPS, much has been developed to manage and control the demand side of the equation in terms of forecasting approaches and the use of techniques such as planning bills and available-to-promise calculations. It is on the supply side that deficiencies are apparent when checking the validity of plans and schedules in terms of available capacity. Little information is provided however, to the extent to which small manufacturing companies suffer from poor MPS performance compared to larger companies.

The task force approach to the redesign of manufacturing systems is outlined by Tobias [55]. This is the approach being used widely in Lucas Industries under the direction of Dr. J. Parnaby, where small teams are set-up to analyse particular product areas, look at what can be improved and then implement the changes they recommend.

Tobias explores the choice of Kanban or MRP, and argues that the choice of manufacturing control system follows fairly readily from the combination of product volume and variety, cost of WIP and degree of flexibility (changeover times).

According to Slack and Correa [56], when describing MPC systems, it is important to distinguish between the general ideas, objectives and assumptions - the "philosophy" - which lies behind each system, and its actual technical mechanism - the "technical core" of the system. These authors suggest that the existing literature does not always succeed in making this distinction clear. Two case studies are provided, comparing the performance of JIT with MRP.

b) Survey-based Research

Kim and Schniederjans [57] introduce the concept of CIJIT, Computer-Integrated JIT production systems. They survey the use of this concept by examining 122 manufacturing firms operating in the United States utilising JIT, CIM or CIJIT production systems. The main industries covered are machinery, electrical, computer, and transportation. This population was divided into 3 groups: one currently utilising only JIT, another utilising only CIM, and the third utilising both systems called (the CIJIT group). These authors found that their assertion that a CIJIT system is more productive, cost efficient and better able to produce a quality product than a JIT or CIM system alone, was supported. There is however, little evidence from the study regarding the suitability of the CIJIT approach to small manufacturing companies.

Cooper and Zmud [58], conclude that it is the relative rather than the absolute advantage of a technology which is important, and as its the relative advantage you are looking for, then assumptions shared by both MRP and reorder point (such as constant purchase lead times) are not of interest.

c) Conceptual Research

Lee [3] argues that future manufacturing systems need to accommodate the best planning features of MRP and the best execution features of JIT to address the changing needs of industry. This author depicts a hybrid production system as a matrix of the functions divided into a planning and execution phase and grouped into the five management activities: demand management; inventory management; capacity management; and quality management activities. No practical examples of the application of this hybrid system are provided in the research.

A conceptual comparison of MRP and JIT for management information systems is provided by Sewell [6]. Sewell argues that much work is heavily focused on the need to effect changes in the internal environment, an area where immediate gains may be more readily realisable, to a point which risks neglecting wider issues associated with the management of relations with the external environment. Yoo [59] also reports that very little attention has been given to the requirements of a supporting management information system for JIT. However, both of these research papers provide conceptual ideas only, and remain untested.

2.2.3. Papers/articles considering one Type of Production Planning and Control System

a) Case Study-based Research

i) JIT Research

The development of an expert system to provide manufacturing companies with recommendations for implementing a sequence of Just-In -Time (JIT) techniques is reported by Fiedler, Gallently and Bicheno [60]. The authors believe there is a definite gap in detailed practical advise available for managers who would like to implement JIT.

The expert system is applied successfully to a U.K. batch manufacturer, but little detail is provided regarding the operating environment of this case site.

Karlsson and Norr [61], discuss the effects of the implementation of a just-in-time system regarding the relations between suppliers and manufacturing companies in the Swedish automotive industry. Their aim is to investigate if such relations can give supply conditions that are more effective or if OEM companies at the end of the manufacturing chain, only push their problems onto the often smaller and weaker part in the two-party relation. These authors introduce the concept of critical time interval SLIP (sequence locking instant to production) and claim that this is a determining factor for JIT relations rather than physical distance. Thus, they find that large geographical distances are no obstacle even for advanced JIT methods such as sequential deliveries.

Millar [62] proposes a Total JIT Strategic Framework, including a manufacturing system, quality system, supply system, material system and human resource system. The framework is applied successfully to an engine plant in the U.K., but no comparisons can be drawn with other production environments.

Oliver [63] considers the experiences of two UK factories in their adoption of JIT and its related practices. Both were engineering concerns, although serving quite different markets. The cases illustrated that the changes involved in a move towards JIT have a profoundly political dimension.

Rainnie [64] examines buyer-supplier relations under JIT, and studies 19 manufacturing units.

Vora, Saraph and Petersen [65] summarise their observations of the JIT implementation process at 14 plants in the U.S. electronics industry, with more than 100 employees, based on personal interviews with plant managers and plant tours. The authors found that pilot programs were very common and useful facilitators of JIT implementation.

The knowledge and experience gained from the pilot were used to adjust the JIT-related change process before expanding it to other products and other areas of operations. None of the plants required massive capital investments to implement JIT. There is no indication from the research that any of the companies under study are small manufacturing concerns.

Ten factories in Spain were evaluated by Zantinga [66], 8 were non-Japanese-owned and operated in the automotive, electrical, electronics, medical and furniture sectors. All employed a repetitive, relatively high-volume manufacturing process, and had started an improvement effort in the last year. The objective of the study was to analyse JIT improvements. The results were then compared with the results of a typical improvement effort in Japan and the average results of 2 Japanese owned factories in Spain (the transplants). The research indicates that factories in Spain have focused their first-year improvement programmes on the factory floor, conceived by the plant manager and executed by industrial engineers.

A paper by Giunipero and O'Neal [67] presents research results highlighting 6 key barriers to JIT-purchasing implementation, the study being validated in a Fortune 500 company in the electronics industry. Gupta [68] provides a feasibility study of JIT purchasing implementation in a large multinational facility.

Hassard and Proctor [69] examine the change process in the introduction of cellular manufacturing in 2 U.K. multinational plants. An alternative framework for the design and implementation of cellular manufacturing is proposed by Afzulpurkar, Huq and Kurpad [70]. These authors' derive some general conclusions from an implementation case study of a large manufacturing facility in North America, regarding the critical success factors relating to a CM project.

ii) MRP Research

Blackstone and Cox [71] argue that the probability of success in implementing and operating a production planning and control system is probably much lower for small businesses. However, an unspecified number of small manufacturing sites are covered in this research.

According to McManus [72], the actual development of an implementation plan for MRP can be viewed as a flow process, the first piece of which is the cost/benefit analysis. McManus provides a detailed analysis of functional and modular sequences for MRP II implementation. The other important tasks in such an implementation are; establishing time frames, assigning resource responsibilities, resource allocation analysis, project management and tracking. The author believes that the most critical element of the entire flow is the monitoring and tracking of the implementation. However, the implementation plan is only applied to a polymer manufacturer in the U.S.

A case study by Torkzadeh and Sharma [12] focuses on MRP application/experience in a small manufacturing firm that adopted an MRP system with an objective of improving inventory control and scheduling. The company is a small company with annual sales of about 10 million dollars. It employs about 60 workers at 2 separate plants located 60 miles apart in Michigan. It manufactures a complete line of point and continuous level sensors for the grain, chemical, cement and plastic industries. The author highlights the fact that selection of MRP followed a recommendation by the production manager. This author also discusses some of the critical issues in the implementation process that require closer attention.

A study by Vargas and Dear [73] focuses on 3 key sources of uncertainty under MRP: variability in end-item demands, that is, demand forecasts; variability in task control, that is set-up and run times; variability in resources supply, that is, equipment breakdown and repair times.

The authors consider 4 buffering strategies investigated to cope with these uncertainties: safety stock located at all production stages; safety lead time for all end and component items; safety capacity, that is, spare installed equipment; forecast inflation, that is, inflating the master production schedule forecasts to "shift" capacity allocations. After conducting simulation modelling, the authors conclude that task control variability is the type of uncertainty causing the most system disruptiveness. End item demand variability is the type hardest to improve upon, and is not quite as responsive to the use of buffers.

Kinnie, Staughton and Davies [74], carry out research in 7 batch manufacturing companies. Their findings point, in particular, to the influence of non-technical, as opposed to technical factors affecting the experience of change in manufacturing strategy. They have a number of practical implications and indicate the need for further research.

In the 9 examples of CIM studied by Smith and Tranfield [75], the authors noted that the implementation of MRPII required attitude change as well as understanding, if the new system is to avoid problems of data capture. These authors categorise the theory of change into morphostatic and morphogenic change. Morphostatic preserves order by treating disturbance as external noise requiring minor adjustments or blocking out. Change in a morphostatic sense is therefore incremental. Morphogenic change treats disturbance as information about the internal conditions and suggests that the system should respond by altering orders. Change produces a logically different order than that which came before.

b) Survey-based Research

Duchessi, Schaninger and Hobbs [76] sampled 272 U.S. companies with MRP/MRPII software, and categorised the factors leading to successful implementation into: top management commitment, implementation process, hardware and software issues.

Cerveny and Scott [77] report on a survey of 433 manufacturing firms in four northeastern states in the U.S. MRP implementors were overall able to make greater strides in controlling inventories and shrinking lead times than nonusers. The degree of perceived success can vary with the definition of success,.

A survey of manufacturing organisations in the Southeast was conducted by Burns, Turnipseed and Riggs [78], which resulted in 238 usable responses from businesses which had implemented MRP. The results of this study indicate that involvement in MRP implementation and the ability to have an input (as measured by the question 'what level of support did you provide for MRP implementation?') result in positive feelings of the outcome of MRP implementation. Correlation analysis was used by the authors' to identify and analyse any significant relationships between the determinant variables and the outcome variables. Determinant variables are those which may be expected to determine feelings or outcomes of MRP. Outcome variables are those representing outcomes of MRP implementation.

Banerjee and Golhar [79] examined the 23 factors which influence the Electronic Data Interchange (EDI) selection decision to identify the differences in motivation for selecting EDI between JIT and non-JIT firms. A total of 50 firms responded to their survey. Of the 50 manufacturing firms using EDI, 25 firms had also implemented the JIT philosophy. Firms in the sample cover a wide range of industries, such as aerospace, automotive, minerals, and chemicals. The authors conclude that considering the number of employees directly involved in EDI implementation and the trend in adding trading partners suggests that JIT firms have a stronger commitment non-JIT firms. JIT firms realise more benefits using EDI than non-JIT firms.

Daniel and Reitsperger [80] examine how JIT and JIC models shape information provision. In a JIT environment, where slack resources are greatly reduced, increasing information flows are of critical importance to make successful coordination possible and to allow effective implementation of the strategy.

JIC promotes the use of slack resources to offset unforeseen contingencies, making information provision less critical. The authors therefore expect more extensive information provision in Japan, since JIT is a component of the Japanese manufacturing model.

Dion, Banting, Picard, and Blenkhorn [81], report the results of an investigation of the changes in the role of the professional buyer that result from JIT implementation. The researchers interviewed two samples of buyers, totalling 60 respondents, either face-to-face or by telephone. According to the authors, the change in a buyer's role can be summarized by stating that he or she becomes less concerned with "getting the best" of the supplier in each transaction and behaves more as a manager of longer-term supplier relationships. The authors also believe that one of the rationales underlying JIT is that to a significant extent logistical coordination replaces inventories.

Freeland [82] surveys JIT purchasing practices in 60 U.S. manufacturing companies in a wide range of industries. The research reported by Giunipero [83] focuses on the types of performance measurement systems used in manufacturing companies and, it analyses the changes required in these systems when used in a JIT operating environment.

According to a report by Ingersoll Engineers [84], compared with 3 years ago (now in 1993), the penetration of cells in UK engineering companies has increased rapidly, and is up by a further 40%. Some 73% of companies employ cellular manufacturing techniques, compared with 51% in the prior survey while a further 7% plan to do so. By contrast, the perceived critical success factors or key inputs to cell introduction were perceived for the most part in 'soft' or people oriented terms. The sample used (75 of which 51 responded) was preselected on 2 criteria: selection against SIC codes (SIC3000-3999) to provide an accurate representation of a cross-section of the UK engineering business as defined by 'sales per sector' (1992) figures. The minimum size was set at £10 million turnover, as companies below this level may be, in effect, cells themselves and the concept needs to be interpreted differently.

Inman and Mehra [85] examine the financial justification of JIT Implementation. A total of 114 questionnaire replies were obtained. Respondents from 31 states represented every geographic area of the continental USA. The sample consisted of many different types of manufacturing firms with large ranges in size from less than 100 to 7,800 employees. According to the authors', the benefits resulting from JIT implementation have been shown to have a significant effect on the financial success of the implementing firms. Results of this study reveal that the level of success reached in implementing JIT accounts for almost half of the variance in financial success.

Keller, Kazazi, and Carruthers [86] regard the most important task in JIT implementation, is the engendering of a universal culture in a company with regard to JIT at all levels from chairman down to office worker.

Vonderembse, Tracey, Tan and Bardi [87], survey current purchasing practices and JIT in 268 U.S. manufacturing companies. The authors claim that firms are re-engineering their purchasing function and that the implementation of JIT acts as a positive moderating factor.

c) Conceptual Research

Bartezzaghi and Turco [30], investigate the applicability of JIT in Italy, with particular reference to small and medium-sized companies.

Quantity and timing logistics are the key external interfaces for the small firm to deal with, according to Brown and Inman [13], in their study of small business and JIT.

Kochhar and Suri [88] present a knowledge based-gap analysis approach which may be used to help with the implementation of effective master production scheduling system.

According to the authors, an essential prerequisite for the practical implementation of the gap analysis approach is the development, testing and validation of the appropriate structured knowledge base, and it is necessary to involve a number of 'real experts' so that the developed knowledge base is based on real industrial practice.

Lin, Krajewski, Leong and Benton [89] examine the effects of environmental factors on the design of MPS systems. The authors consider a cost model of MPS in single item, made to stock in an uncertain environment.

Murthy and Ma [90] comment that the early literature dealt with deterministic MRP, that is, MRP in a deterministic framework. However, according to the authors', in the real world, many forms of uncertainty affect the production process. As such, deterministic MRP is inappropriate for most situations, which has led to the development of MRP with uncertainty, that is, MRP in a stochastic framework. The authors` review of the literature leads to classification of sources of uncertainty; and the method of planning with uncertainty. Schlussel [91] links performance measures to Critical Success Factors (CSF).

Chan, Samson and Sohal [92] construct an integrated model of JIT, using a contextual (holistic) approach consistent with the holistic nature of Japanese manufacturing techniques. It proves a new and comprehensive model of Japanese manufacturing techniques; extending Lockyer's integrative model based on the five Ps (product, plant, processes, programme and people) management.

By using this approach, the authors' hope to avoid the difficulties to which many previous studies and practical implementations have fallen prey, which is to attempt to decompose the Japanese system and adopt only those elements which seem directly relevant. The comprehensive model proposed in this article provides the basis for recognising positive multipliers and synergy's which can be achieved through comprehensively embracing the Japanese based systems successfully.

Goyal and Deshmukh [29] review the literature on JIT, and identify possible research portfolios in the field.

Harber, Samson, Sohal and Wirth [93] outline the antecedent principles underpinning JIT and the fundamental issues affecting JIT programmes

Lummus & Duclos-Wilson [94] suggest that an audit of a facility and an associated JIT-implementation plan will determine the effectiveness of the JIT program.

MacBeth [95] presents a JIT research model, where the macro level of the study concentrates on organisational, financial and manufacturing policy with respect to the developing supplier/buyer relationship. The micro level concentrates on product quality, logistical reliability, product flexibility and information flow. MacBeth presents the need for research into the management of the supply chain to JIT producers and the research topics on that agenda.

The use of a JIT rule base is advocated by Pegler and Kochhar [33]. A set of rules are presented which can be used either as an educational tool to inform on the elements and subelements of JIT or as an aid to ensure that a thorough and systematic approach is taken to the implementation of JIT.

The discussion of JIT implementation problems can be simplified, according to Safayeni, Purdy, van Engelen and Pal [96], by classifying the efforts towards JIT into four levels. The levels are organised along a continuum from a minimum to a maximum level of implementing JIT. Each level may be considered as a discrete category representing a general state of affairs with respect to JIT implementation in an organisation. Level one is education or "talking JIT", level 2, a pilot project, level 3, modified JIT, and level 4, is the achievement of total JIT.

Heiko [35], develops a simplified conceptual framework for JIT consisting of one objective and 4 implementing principles.

The objective is the design and management of a production system to minimize production lead time. The four implementing principles are; streamline manufacturing operations, control for total quality, leverage with worker creativity, and integrate JIT with MRP.

According to St. John and Heriot [14], most of the current published material focuses on the implications of JIT for the manufacturer that implements the system. A notable omission is the impact of JIT manufacturing on the purchasing relationship that exists between JIT manufacturers and their small business suppliers. These authors' derive what the company needs from its supplier, and what unique capabilities can be offered by potential small suppliers, by means of a two by two matrix model.

JIT purchasing articles are classified into 3 categories by Stamm and Golhar [97]: conceptual, case and empirical

The examination of the change process towards JIT presented by Willis and Suter [98] involves 5 phases, the so-called 5 M's of manufacturing. The authors' believe these to overlap; mindset, motion, movement, materials, momentum.

2.3. Summary

This chapter has highlighted the lack of validated frameworks and models for the selection and implementation of production planning and control systems, especially in small manufacturing companies. There is also a remarked absence of action research and longitudinal studies into selection and implementation criteria. The literature does, however, provide a wealth of detail on the characteristics necessary for successful selection and implementation of production planning and control systems. These characteristics shall now be identified in chapter 3.

Chapter 3

Literature Classification Analysis

3.1. Introduction

It is the objective of this chapter to categorise the existing literature on production planning and control systems. It is intended that one of the most important contributions of this work be the development of a framework for the selection, implementation, and improvement of production planning and control systems in small manufacturing companies. The content of such a framework is going to rely heavily on identifying, from the literature, the characteristics which influence, either negatively or positively, the selection and implementation process. In addition, as stated in chapter 1, the framework should also highlight improvements in the existing production planning and control system, thus further broadening the literature review task.

3.2. Categorisation Process

Given that this review should result in the content of the framework, a form of categorisation should be provided. To aid testing and validation of the framework, the following categorisation scheme will be used:

Strategic Issues
Product Issues
Process Issues
Capacity Issues
Inventory Issues
Workforce Issues
Quality Issues
Supplier Relations Issues
Customer Relations Issues

This categorisation process will make it easier to direct questions to the appropriate people in different manufacturing companies. In addition, the intention is to approach the selection, implementation, and improvement of production planning and control from a Supply Chain Management perspective, hence the identification of both supplier and customer issues will facilitate this. Hence, the internal and external characteristics of the selection, implementation and improvement process will be covered.

Appendix 2 summarises the literature reviewed in this chapter.

3.2.1. Strategic Issues

The literature on strategic issues can be categorised under four subsystems, namely; measures of performance, benchmarking, cost control and manufacturing strategy. The characteristics identified within the literature will be presented under each of these subsystem headings.

Measures of Performance

Kaplan and Norton [99] announce that the traditional financial ***performance measurements*** worked well for the industrial era. but are out of step with the skills and competencies companies are trying to master today. These same authors introduce a balanced scorecard which asks a company to answer 4 basic questions about itself. On the other hand, Lee and Billington [100] address the common pitfalls in managing supply chain inventory, including the lack of supply chain metrics. Each function or company may have their own objectives, but these may have little to do with the supply chains overall performance. Those that do have supply chain metrics often do not monitor them regularly.

According to Kivijarvi and Tuominen [101], one way of building performance measures is to divide the logistics system into 3 subsystems; namely; supply system, operating system, and a distribution system. Meanwhile, Bartezzaghi and Turco [30] highlight the main issues in performance measurement.

In JIT, performance trends are more important than absolute levels of performance, according to Hendricks [102], who suggests that the dominant principle is that each performance measure should be directly linked to a critical success factor. According to Sweeney [103], the selection of the key performance indicators to be used also has a profound impact on organisational behaviour, with performance measurements being instruments designed to trigger the management of change. The same author also advocates questioning the appropriateness of the current measures of performance within a company. He finds argues that some key manufacturing performance indicators can become permanent fixtures within a business and continue to be used without an adequate questioning of their appropriateness.

Benchmarking

According to Partovi [104], the crucial stage in the ***benchmarking*** process is at the beginning, that is, determining which function to benchmark. Daugherty, Droge, and Germain [105], successfully test 4 hypotheses regarding benchmarking. Ohinata [106] discusses the limitations of benchmarking, especially when the process takes on a 'copycat' form. This author outlines the key success factors for benchmarking. Sweeney [107] believes that the choice of key performance indicators to be used for benchmarking purposes must be based on how well they measure customer satisfaction or how well the information generated by their use will facilitate the achievement of customer satisfaction, and, an understanding of both the current and prospective role of the company in the supply chain. Mosquera & Lange [108] discuss a benchmeasure technique which is particularly geared towards small and medium sized companies which often lack the ability or resources to drive a full benchmarking study. According to Partovi [104], there are 2 main types of benchmarking; product and process. The same author shows 4 ways of identifying partners.

Cost Control

Daniel and Reitsperger [80] show that innovative Japanese manufacturing techniques such as JIT have been implemented by suitably adjusting ***management control systems***. Specific goals and performance feedback are the core elements of such a system. Daley, Jiambalvo, Sundem and Kondo [109] empirically examined attitudinal differences between line mangers and controllers in the US and Japan in regard to budgeting and control systems. Their findings revealed that common notions about Japan, such as participation of workers in the budgeting process or preferences for unit quantities over cost information were not supported by empirical evidence.

Kaplan [110] found traditional US management accounting practices unsuitable to meet the needs of modern innovative manufacturing and Hiromoto [111], found that Japanese management control systems have been modified to reflect and promote strategic objectives. The lack of compatibility between accounting and manufacturing has become known as the "productivity paradox", according to Green and Amenkhienan [112].

Harmon [113] believes that the Japanese are gravitating toward the elimination of standard cost in favour of estimated cost at the end product level. Primrose, [114] outlines the intangible benefits to be gained from MRP II implementations, with the problem having now changed from the inability to include benefits, to the accuracy with which they can be estimated.

Greenwood and Reeve [115] outline the current limitations of ***activity-based costing*** (ABC). The introduction of ABC into supplier development will provide information on cost distortions, and identify areas for continuous improvement, and this will improve cost effectiveness of procurement from key suppliers, suggest Winters, Steeple, and Sara [116].

Takikonda [117] suggests that pull control requires ***process costing*** systems and not job costing. Job costing requires a great deal of discrete tracking of information and it is difficult to obtain the cost accounting information until the work order is completed, which may not be timely. JIT is not JIT if a company continues to use traditional methods of measuring efficiency and productivity, report Lummus and Duclos-Wilson [94].

Manufacturing Strategy

Manufacturing Strategy is an issued raised by a number of authors. According to Hayes and Pisano [118], a key role for a company's manufacturing strategy is to guide the selection of improvement programs. The need for more conceptual frameworks and concepts about the process of manufacturing strategy is advocated by Anderson, Schroeder and Cleveland [119]. The inconsistency between the marketing and manufacturing management's visions of how the corporate objectives of the business could be accomplished is broached by Sweeney [103]. Watts, Kim and Hahn [120] propose that purchasing and manufacturing strategies must be consistent with each other, and they must be able to support the corporate level competitive strategy.

Garvin [121] introduces strategic manufacturing initiatives (SMIs), which drive improvement and are inherently dynamic. Strategic controls are not only critical in the strategic planning process but are also relevant to motivation, report Daniel and Reitsperger [80]. Oliver [36] suggests that manufacturing system-market interactions are poorly understood. Indeed, according to Berry and Hill [9], the key to designing Manufacturing Planning and Control Systems (MPC) which fit the business is to link: markets, processes and MPC systems.

Monczka and Trent [122] identify the ***stability of industry*** as being an important characteristic. In particular, a firm must be able to identify which category (stable, moderate or dynamic change) applies to its industry and its unique situation for each competitive factor.

In addition, Harber, Samson, Sohal and Wirth [93] comment that for a wider implementation within a particular industry sub-group, for example, vehicle manufacture, there is a requirement for a suitable industrial infrastructure to implement the full-scale JIT approach.

St. John and Heriot [14] deal with the issues of product environment. These authors produce a two by two matrix for ***standard product environments***, where a JIT buyer needs to understand exactly what the company needs from its supplier, and what unique capabilities can be offered by potential small suppliers. On the other hand, in a ***non-standard product environment***, from a buyer's perspective, a potential supplier can stand out from its competitors in several ways: quality that exceeds all industry standards, offering unique products, or having an extraordinary design capability.

The characteristic of ***focused factory*** is raised by Bozarth [123] and Taylor [124]. Bozarth produces three hypotheses concerning operation focus: higher internal consistency among manufacturing characteristics will have a positive effect on individual dimensions of manufacturing performance: higher internal consistency among marketing requirements will tend to have a positive effect on the internal consistency of manufacturing characteristics: higher levels of market/manufacturing congruence will have a positive effect on overall manufacturing performance. Taylor, outlines a plan for developing focused systems.

According to Baker [125], manufacturing organisations in Europe and USA need to restructure their operations to achieve a higher standard of ***value-adding capability*** and energy utilisation. A time-based framework has been developed capable of analysing existing operations and guiding investment and continuos improvement. Blackburn [126] argues that to be a true-based competitor, a firm must shrink the entire chain by time compressing activities that also lie outside the factory walls.

These are the activities of the "white collar factory". Meanwhile, Dilton-Hill and Glad [127] announce that the value chain is split between primary processes (that is, processes that design, produce, market, and support a company's products and services) and secondary processes (that is, processes that support the primary processes).

3.2.2 Product Issues

The literature on product issues can be categorised under three subsystems, namely; demand data, design and Master Production Scheduling. The characteristics identified within the literature will be presented under each of these subsystem headings.

Demand Data

Forecasting accuracy is identified by Handfield and Pannesi [128], as a critical component of demand management, which provides the link between the planning and control system and market demand. Fildes [129] outlines the reasons for limits to forecast accuracy, and the same author also outlines ways of overcoming the barriers to improved forecasting:

A high rate of ***revision of customer demand*** highlights the need for effective logistics and responsive control systems, report Kochhar and McGarrie [7].

Design

When introducing new products, the implications for supply chain inventory are usually ignored or poorly understood, according to Lee and Billington [100], and consequently, products should be ***designed with Supply Chain Management in mind.***

Flynn [130] proposes that one of the main approaches to the achievement of fast product innovation, is ***concurrent engineering***

Kochhar and McGarrie [7] found that a ***design for manufacture/assembly approach*** is essential for the formulation of cells, and for the use of pull control. It also helps with the implementation and operation of all types of control systems. Design for manufacturability is also identified as one of the key issues on JIT's improvement path by Maes and Van Wassenhove [26], and design for manufacturability has reduced time to ramp-up to full production as its goal, according to Flynn [130].

Computer aided design significantly adds to product flexibility, according to Herroelon and Lambrecht [15]. Bohse and Harhalakis [131] remark that CAD and MRP II have not yet been integrated in any commercial system for many reasons.

Modularised design is identified by Herroelon and Lambrecht [15], as being of crucial importance, with detailed end product specifications being postponed to later stages in the manufacturing process. The dichotomy between inventory reduction and product variety is explored by Bennett and Forrester [132] .

The Critical Success Factors for the ***introduction of new products*** are discussed by Cooper, and Kleinschmidt [133] , and Cusamano [134] outlines the principles of lean management, illustrating the Product Development aspects by reference to the Honda Model.

The ***product introduction rate affects*** the choice and suitability of capacity planning and scheduling, and of pull control, according to Kochhar and McGarrie [7], with a low introduction rate indicating the appropriateness of pull control, a high rate indicating the need for a sophisticated capacity planning and scheduling function.

Benton and Srivastava [135] report that ***product structure complexity*** can be represented in 2 ways: breadth complexity and depth complexity. Breadth is represented by the number of immediate components per parent; depth can be represented by the number of levels in the BOM structure. Where a high number of BOM levels exist in the product structures of a company, MRP becomes necessary to facilitate the accurate explosion of the BOM's suggest Kochhar and McGarrie [7].

Similarly, in engineering industries, MRP systems are implemented because of the large numbers of subassembly stages and different component items per product and the wide range of end products produced, according to Lambrecht and Van den Wijngaert [136]. The disadvantages of managing low level components, that is, dependent demand items with ROP techniques grow in proportion to the number of levels, according to de Toni, Caputo, and Vinelli [137]. Orlicky, Plossl and Wight [22] provide a seven point checklist for reviewing bill of materials, and state that the B.O.M. must be unambiguous and so structured as to lend itself to MRP, with the mere existence of a bill of material being no guarantee that MRP will actually work.

A large ***number of variants per product*** results in the need for a good MRP system and indicates the need for modular bills of materials, according to Kochhar and McGarrie [7]. It also results in the complexity of all the control functions being increased, leading to difficulties in operation.

A low level of ***product family categorisation***, increases the need for control over functions of capacity planning and scheduling, and shopfloor control is emphasised, advocate Kochhar and McGarrie [7], whereas, with a high level of product family categorisation, pull control becomes possible, with the formation of cells becoming easier, supporting the view of Heard [138].

Kochhar and McGarrie [7] also identified the characteristic of a high ***level of engineering changes*** and the lack of a disciplined engineering change procedure, which affect the data integrity and thus the performance of all the control functions. This supports the view of Kanet [139] who highlights the importance of a disciplined engineering change procedure for successful operation of inventory control and MRP. Harhalakis [140] highlights the lack of literature on engineering change control for engineered products. Decreased lot sizes insure that engineering change notices can be implemented faster so that the customer receives the current, up-dated version of the product sooner, according to Hannah [5].

Related to engineering changes, is the characteristic of **effectivity dates**. Kanet [139] identifies these as being critical, engineering changes being endemic, that is, with many companies, marketing and engineering change is a way of life. Because of this, special efforts are needed to monitor and control the 'excess' inventory caused by the accommodation of engineering changes.

No Master Production Scheduling characteristics

3.2.3. Process Issues

The literature on process issues can be categorised under five subsystems, namely; lead times, production flow, cells, maintenance and, technology and flexibility. The characteristics identified within the literature will be presented under each of these subsystem headings.

Lead Times

Good pull control and inventory control are required to achieve the objective of short ***commercial lead times,*** according to Kochhar and McGarrie [7]. Gardiner, Blackstone and Gardiner [27] highlight the problems with existing production planning and control systems, for example, DBR (Drum-Buffer-Rope) systems usually use lead times roughly three times the total processing time for a part, and MRP systems use lead times roughly ten times the total processing time.

Handfield and Pannesi [141], suggest that ***delivery speed and reliability*** are unique manufacturing strategies (within the context of planning systems) in the job shop/batch environment.

Vastag and Whybark [142] suggest that ***manufacturing lead time*** will increase with work-in-process inventory. Toyota's Lean Production model is highlighted by Cusumano [134]. According to Christopher and Braithwaite [143], the concept of strategic lead time is simple: How long does it take to convert an order into cash?

Production Flow

According to Kochhar and McGarrie [7], in low ***volume*** situations, the scheduling problem becomes more complex, whereas in high-volume situations, scheduling is less complex and pull control becomes more very suitable for controlling large, repetitive volumes. Tobias [55] explains that it is generally accepted that traditional 'push' systems such as MRP are appropriate to medium/low volume, high variety production, with on the other hand, pull systems (kanban) primarily serving high volume/low variety environments.

A low ***number of manufacturing operations and shorter routings***, results in a need for simple capacity planning and scheduling and for shopfloor control, according to Kochhar and McGarrie [7], with a high number increasing the complexity of, and highlighting the need for complex capacity planning and scheduling, and for shopfloor control. These same authors also identify the ***number of works orders*** and ***alternative routings and processes*** as key characteristics. A large number of works orders indicates the need for good capacity planning and scheduling and for shopfloor control. Alternative routings and processes indicate a need for detailed capacity planning and scheduling. In such circumstances, there is an increase in the complexity of the capacity planning and scheduling, and shopfloor functions, due to an increase in the data requirements.

Set-ups have been identified by a number of authors. Oliver [63] states that for a JIT system to operate successfully, swift machine set-ups are clearly an essential element. Similarly, fairly short set-ups are a major factor when pull control systems are to be used in cellular manufacturing environments, according to Kochhar and McGarrie [7], supporting the views of Sugden [144]. Lummus and Duclos-Wilson [94] believe that reductions of only 5-10% are an indication setup time has been overlooked in the JIT implementation. Daniel and Reitsperger [80] announce that reductions in setup time make it economically feasible to produce increasingly smaller lot sizes, thus decreasing inventory levels, while at the same time allowing flexible responses to market changes.

Cells

According to Maes and Van Wassenhove [26], JIT relies on highly ***decentralised shop floor control***. OPT, is totally different as orders are prepared for release based on finite loading calculations by the system. In this strictly centralised system, all dispatching is scheduled in advance. MRP is somewhere in between, according to the authors.

According to Afzulpurkar, Huq and Kurpad [70], ***Cellular Manufacturing*** (CM) is a prerequisite for JIT manufacturing, with the applicability of CM usually indicated by the following characteristics of a manufacturing firm: variety and complexity of the firm's product line, and demand patterns for the firm's products. The same authors arrive at some general conclusions can be drawn regarding the critical success factors relating to a CM project, and note that before making a move to a cellular layout, the constraints imposed by computer-based MPS/MRP systems, should be identified. A switch from a functional organisation of production to a product or flow line basis in order to simplify the work flow is typically advocated for JIT by Daniel and Reitsperger [80]. Kochhar and McGarrie [7] conclude that with a high degree of cellular manufacturing, there is an obvious requirement for pull control, with MRP being used to generate the requirements for parts.

Any manufacturing cell must have a structured interface to the rest of the organization according to Prickett [145], who also highlights the first rule of cell design and implementation, which dictates that products should be grouped into identifiable families, each of which should then be manufactured within an identified manufacturing area or cell. Rao and Scheraga [146] state that equipment can either be relocated to form physical cells, or simply be allocated to JIT production to form logical cells.

The use of the ***kanban*** system is advocated by Maes and Van Wassenhove [26], with the WIP buffers present in a Kanban system equal the container size times the number of kanbans released. Dedicated JIT lines make sense when capacity is cheap and volumes are high, suggests Schonberger [147].

Biggest gap in management tools such as MRP II, is the lack of effective finite capacity scheduling, and inability of computer systems to contribute much to 'what do we do next?' ***shopfloor decision-making process***, suggests Burgoine [148]. Donovan, [149] highlights the fact that he more complex the product and process environment, the more difficult the problems become using finite forward scheduling or infinite for that matter.

The ***reasons for changing schedules*** need to be identified and the underlying problems resolved, according to Bennett and Forrester [132], with the goal of reliable schedules to be created and strictly adhered to. Linking into this characteristic is a disciplined approach to manufacturing control systems, necessary in order to prevent a lack of confidence emerging in the systems with the consequent proliferation of informal procedures to attain results, and advocated by Kochhar and McGarrie [7], and Hall [150].

In production planning and control systems, it becomes necessary to make use of a ***priority assignment system*** in order to decide which order, among those destined for the same manufacturing centre is the most urgent, comment de Toni, Caputo, and Vinelli [137]. A closer comparison between MRP and JIT, by Gelders and van Wasenhove [151] reveals an important distinction in the way that each approach handles the prioritisation of the production of particular products and how each deals with the issue of capacity constraints. JIT is, by nature, the simplest possible prioritising system, as products are only made as when needed with the assembly process being managed by a visual control mechanism (often using kanban cards) for WIP. MRP develops a prioritisation schedule from a Master Schedule by employing optimisation techniques which take into account historical lead times and levels of safety stock.

Maintenance

Machine breakdown, in leading to increased uncertainty, has a detrimental effect on the performance of capacity planning and shopfloor control functionality, according to Kochhar and McGarrie [7]. In addition, the inherent nervousness of MRP systems is increased, as confirmed by Minifie and Davis [152]. Uncertainty with respect to machine downtime makes for rerouting flexibility which is the degree to which the operating sequence through which the parts flow can be changed, defined by Gerwin, [153]. According to Daniel and Reitsperger [80], machine downtime is also an important factor affecting JIT implementation, since machine breakdowns or setups in the absence of buffer or safety inventories will cause production interruptions. Gallimore and Penlesky [154] suggest that process facilities should be designed so that they are reliable and easy to maintain, and that the ***maintenance strategy*** adopted should have the ability to adapt when new equipment or model changes are incorporated into the manufacturing process. Maintenance is rapidly evolving as a major contributor to the performance and profitability of manufacturing systems, with Maggard and Rhyne [155] estimating maintenance representing 10-40% of production costs. These same authors describe the implementation of TPM (Total Productive Maintenance).

Technology and Flexibility

The use of ***AMT*** simplifies the capacity planning and scheduling and the shopfloor control problems by reducing the number of manufacturing operations, according to Kochhar and McGarrie [7]. Indeed, where the use of AMT creates a bottleneck problem, the complexity of scheduling is also increased. The use of AMT also helps with the creation of cellular systems, and hence the implementation of pull type of control.

3.2.4. Capacity Issues

Few references are made to capacity issues within the existing literature, therefore no subsystems have been allocated to this section of the review.

Towill, Naim, Wikner [156] suggest a design guideline which is often quoted, that the ***planned 'steady state' capacity*** expected from the plant should never exceed 80% of the achievable maximum. The same authors also highlight the fact that for JIT implementation, shopfloor loading (in terms of volume) should be virtually constant.

One strategy used by a number of transplant assemblers in the U.S. is to hire a significant number of temporary workers who are used as a buffer and let go when production cutbacks are implemented, while permanent employees are retained, according to Florida and Kenney [157]. On the other hand, Gelders and van Wassenhove [151] come to the conclusion that JIT simply raises its overall capacity to accommodate fluctuations in demand either by increasing throughput or adding more productive cells. These same authors also arrive at the conclusion that MRP responds to fluctuations in demand by juggling production between fixed capacity - optimising decisions are made about the product mix of WIP by taking the Master Schedule and heuristically deriving a Capacity Planning routine to mix the load across the various workcentres. According to Kochhar and McGarrie [7], if a plant is consistently working at or near to its full capacity, then a form of detailed capacity planning is required. However, this can cause extreme problems with data gathering and integrity. McNair [158] suggests that setting a theoretical limit establishes a clear and unambiguous benchmark to strive for in managing the resources of the plant.

Chan, Samson and Sohal, [92] present ***industrial engineering*** as part of their integrative model for the JIT philosophy.

Herroelon and Lambrecht [15] investigate the reasons for MRP failure on an operational level, and blame, to a large extent, capacity constraints, which are ignored.

The authors believe that the widespread use of ***RCCP*** may be a good capacity check at the planning stage, but that in many cases, this is not enough. Marucheck and Peterson [40], outline the benefits to be gained for a small company, when using spreadsheets.

A high ***number of bottlenecks*** indicates the need for detailed capacity planning and scheduling, according to Kochhar and McGarrie [7]. The OPT system helps by identifying problems and scheduling the work appropriately. When the number of bottlenecks in the system is low, there is still a need for capacity planning and shopfloor control. Gardiner, Blackstone and Cox [27] summarise the DBR/buffer management approach. Similarly, Fawcett and Pearson [28] suggest that for constraint management to be most effective, both internal and external constraints must be considered. The total number of constraint resources in most, even large, facilities is usually quite small, often fewer than 5 or 6. Indeed, product flow, and inventory levels within the small manufacturing facility are determined by only 1 or 2 such resources. Constraint management is a specific application and extension of Pareto's Law, which states that a few items will have a disproportionately larger impact on a system than the remaining majority of items.

3.2.5. Inventory Issues

The literature on inventory issues can be categorised under four subsystems, namely; inventory data integrity, MRP, scheduling and MPS. The characteristics identified within the literature will be presented under each of these subsystem headings.

Inventory Data Integrity

Data accuracy and integrity are vital to the successful implementation and operation of the manufacturing control systems under consideration, report Kochhar and McGarrie [7], as confirmed by Kanet [139], and, Blackstone and Cox [11].

Proud [159] also reports that MRP needs accurate data (records), B.O.M's, on-hand balances, and open order status's, which need to be properly monitored or maintained to assure credible input. Pacos and Sinn [160] advocate the use of accountability and training to obtain integrity of data. Ptak [1] believes a large portion of the total resource of the system is dedicated to the maintenance of accurate status within the system. Sewell [6] expands on this by exploring the 'back door' where the materials flow in and the 'front door' where the commodities are despatched to the customers, constituting the boundaries with the external environment. In a similar vain, Yoo [59] comments that the effectiveness of MRP depends on the availability of valid input, and according to Gelders and Van Wassenhove, [151], MRP has a virtual unavoidable susceptibility to data input error.

Delays in information retrieval and transmission are a major problem in Supply Chain Management, according to Lee and Billington [100]. Execution of MRP usually takes a long time. This entire process forced the manufacturer to plan monthly. Manufacturer ends up building the wrong products.

One of the most critical requirements for JIT implementation is an ***effective information system***, suggests Yoo [59]. For one thing, there are some who assumed that JIT sometimes called Kanban can be implemented without the aid of a management information system. However, Kanban can only be activated after detailed production schedules are ready. Daniel and Reitsperger [80] expand upon this point by outlining the fact that in a JIT environment, where slack resources are greatly reduced, increasing information flows are of critical importance to make successful coordination possible and to allow effective implementation of the strategy. Kim [161] discussed a periodic pull system, where the manual information processing time of a kanban method is replaced by on-line computerised processing. Kim and Schniederjans [57] introduce CIJIT, computer-integrated JIT production systems. Implementing a CIJIT purchasing system requires the physical support of an automatic identification system (AIS). Plenert [53] defines a world manufacturing information flow model.

When there is a need for 100% ***material traceability***, the functions of MRP, inventory, purchasing and shopfloor control all become necessary as a result of the large data and archiving requirements, according to Kochhar and McGarrie [7]. Procedures can also be devised to provide traceability in cellular manufacturing systems.

The annual stock-take is not a very good method for maintaining inventory accuracy according to Neeley [162]. The use of ***cycle-counting*** is advocated by Reichart [163], who suggests a creative and imaginative analyst should be assigned full-time to tracking down the source of all errors uncovered by the cycle-counting or any parts shortages. Graff [164] also explores cycle-counting, and believes if a cycle counting program is structured to give the cycle counters sole responsibility for finding and correcting errors, a counterproductive attitude can easily develop among the other stockroom employees and material handlers. These people can loose their sense of accountability; the feeling that inventory accuracy is their responsibility. If that happens, failure is virtually guaranteed.

Another inventory analysis technique identified from the literature is the ***ABC classification method.*** Typically, A accounts are allowed 0.5% monetary deviation, B 1% and C 5%. From a financial viewpoint, ABC assignments are arbitrary because aggregate inventory accuracy depends on the relative monetary value of each class. The overall accuracy is a weighted average of the 3 classes, according to Martin and Goodrich [165]. Graff [164] also believes the ABC approach to be questionable on 2 counts; the phenomenon of lumpy demand works against having loose tolerances on C items; and, verifying the accuracy of A items alone does not assure the accuracy of overall inventory.

According to Elliot [166], all ***part numbers should be non-significant***, as the use of significant part numbers increases the possibility of data errors entering the system.

South and Hansen [167] believe companies should aim for 'zero excessive inventory' rather than zero inventory. Dillon [168] outlines the ***costs associated with inventory***. The same author also notes some simple steps for the planner to take, rather than long-term projects. Lockyer and Wynne [169] detail the reasons for long stock life. Toelle and Tersine [170] further contribute to the debate by highlighting their causes of excessive inventory: These authors make a significant contribution to the literature by detailing what excess inventory is. The opportunity cost of inventory should include the opportunity cost of capital, warehousing and storage, according to Lee and Billington [100]. Natarajan [171] suggests that a better indicator of inventory costs is 'dollar days', and that inventory costs are determined not only by the level, but also by the duration of time the materials spend in the system. This author uses a cause and effect diagram to organise all of the information about the various factors that influence inventory costs. Kochhar and McGarrie [7] found that the existence of a high number of high-value items indicates the need for good inventory control and purchasing systems to minimise loss.

Benton [172] examines the purchasing manager's methods for making ***quantity (lot size) decisions***. The research classifies some of the significant literature on purchase lot sizing, discusses numerous variations of the purchase lot sizing literature, provides a taxonomy, and summarises the results of the review. Jones [173] concludes that, although the EOQ formula is mathematically rigorous and correct, its practical application by manufacturers habitually leads to a miscalculation of optimum lot sizes, and Haddock and Hubicki [174] announce that manufacturing operations are implementing MRP systems which use simplistic approaches to establishing lot-size quantities. Several reasons are given by the author for this paradox (despite researchers proposing numerous ways to make lot-sizing decisions). Overall, though, Saunders [175] comes to the conclusion that while the basic EOQ model is relatively simple and easy to use, it is based upon assumptions that may not be realistic in many situations, namely, that demand and reorder lead times are constant. This does not allow for consideration of the reorder point or stockout costs and hence is somewhat limited in its realism.

Lee and Billington [100] develop the idea that inventory stocking policies should be periodically adjusted to reflect changes in the environment.. Companies commonly use generic stocking policies, for example, all A's, 3 weeks safety stock held, and for B items, 4 weeks safety stocks are held. This classification of items by transaction volume does not necessarily reflect the magnitude of uncertainties in supply and demand.

The need for a mechanism is still needed to reduce inventories without creating shortages of the essential items needed to meet finished product demand. According to Bennett and Forrester, [132] tactical ***buffering*** is a means of more effectively managing these inventories under low volume conditions. The key idea from Oliver [36] is that JIT does not and cannot eliminate all slack from a production system (an espoused goal of JIT). Although reducing the total amount of slack in the system JIT also involves a redistribution of the slack which remains. According to Maes and Van Wassenhove [26], MRP buffers can be physical or a time buffer obtained through inflated lead-times or through hedging the master plan. Highly related to buffers and lotsizes is the amount of WIP in the system and the way it is controlled.

In the study by Kochhar and McGarrie [7], a large ***number of transactions*** indicates the need for some sort of computer-based system in order to process all of the data involved. Depending on the individual functions which involve a large volume of transactions, it may be necessary to implement appropriate functions of an MRPII system, such as MRP, inventory, purchasing, scheduling and shopfloor control. Waples and Norris [176] propose the use of back-flush costing to necessitate strict control over inventory between trigger points and accurate material records.

MRP

Murthy and Ma [90] make a significant contribution to the literature by analysing the impact that ***uncertainty*** has on MRP. The early literature dealt with deterministic MRP. the development of MAP with uncertainty, that is, MRP in a stochastic framework.

McManus [72] makes a major contribution to the literature by outlining the ***MRP II implementation process***. However, according to Burns, Turnipseed and Riggs [78], with the availability of packaged software, the emphasis has shifted from the development of the manufacturing information system to its evaluation, purchase, and implementation. Cerveny and Scott [77] conclude, that the degree of perceived success can vary with the definition of success. Duchessi, Schaninger and Hobbs, [76] identified factors leading to successful implementation, and organised them into 3 categories: top management commitment, implementation process, hardware and software issues.

Blackstone and Cox [71] discuss the selection of a particular ***type of MRP*** system. A regenerative system performs a complete analysis of all inventory items whenever the main program is run (usually once every week or two). A net change system will update the status of any items affected by a change in data, without considering other items. A net change system has the advantage of containing more current information.

The primary prerequisites on which MRP is predicated are highlighted by Vargas and Dear [73]. These assumptions are quite stringent and failure to have them present will hamper the effectiveness of the MRP methodology. Further material on uncertainties is provided by De Toni, Caputo, and Vinelli [137]. Donovan [149] highlights the most critical questions of manufacturing control that cannot be answered by standard MRP II.

Scheduling

An examination of many ***JIT programs*** by Lummus and Duclos-Wilson [94] reveal that most plants claiming JIT status have implemented only a portion of the philosophy. The implementation plans are not plant wide in scope. Safayeni, Purdy, van Engelen and, Pal [96] observe that JIT efforts are often embedded within a process which requires the generation of information about accomplishments within a certain period of time.

Millar [62] presents a Total JIT Strategic Framework with subsystems within the manufacturing system, the quality system, the supply system, material system, human resources system. Within this framework, Millar believes the priorities can be identified and prioritised by answering the following questions:

Similarly, Karmarkar [177] reports that most advanced manufacturing companies find that they require a ***hybrid system*** of shopfloor control systems - tailored systems, including innovative pull systems, like kanban, as well as time-tested computer driven push systems like MRPII.

MPS

A poorly managed ***master production schedule*** can lead to system failure, according to White [178]. Malko [179] highlights a number of points which should be taken into consideration when deciding who should master schedule. Burcher [54] provides an in-depth investigation of the information that companies actually use to create their Master Schedule. Malko also highlights 5 major sources for changing the MPS. Kochhar and Suri [88], examine the implementation of MPS system via a gap analysis and conclude that it is necessary to consider a number of high level issues.

3.2.6. Workforce Issues

The literature on workforce issues can be categorised under three subsystems, namely; change management, education and training, and organisational structure. The characteristics identified within the literature will be presented under each of these subsystem headings.

Change Management

According to Florida, and Kenney [157], giving workers ***broader tasks***, increases the their interchangeability, increases their skills and allows them to develop a more comprehensive view of the production process.

The job design process employed by the Japanese, conflicts with "Scientific management", since it features a degree of worker participation, as described by Conti and Warner [180]. This *"soikufu"* (creative thinking) approach to job design in Japan is described by Heiko [35]. According to Sayer [181], a JIT/TQC system encapsulates 3 distinct forms of flexibility. Dawson and Webb [182] broach some largely ignored but important concerns of production workers and managers, focusing on the replacement of traditional work disciplines rooted in the notion of 'time-is-money' with a new philosophy of working only to meet customer demand and to create process improvement. In research by Willis and Suter [98], when examining the move on the shopfloor to flexible working and cells, it was found that flexible working was resisted by some sectors of the shopfloor on the grounds that it would lead to the erosion of skills, and hence bargaining power, a concern particularly prevalent amongst skilled workers. In a study by Bratton [183], when skill enhancement did take place it was restricted to the "core" group of skilled workers; the semi-skilled and unskilled workers were disadvantaged by the flexible work arrangements. Kochhar and McGarrie [7] found that the existence of a highly skilled workforce is very important for the successful implementation and operation of both pull control and OPT. Woodcock and Weaver [184] profile 4 meanings of worker competence. A common ground of flexibility was found by Mueller [185] when examining new industrial relations in the European automotive industry. Parthasarthy and Sethi [186] emphasise two types of flexibility. There are few job classifications for workers in Japanese plants, in contrast to the dozens found in traditional US automobile assembly plants, according to Florida and Kenney [157].

A key feature of the Japanese system, according to these same authors, lies in the fact that shopfloor workers are seen as a source of ideas and constant improvement innovations. A study by Inman and Boothe [187], found that the quality circle is not an integral part of every single JIT implementation, nor can it be said that most JIT firms utilise it.

Hiltrop [188] discusses 2 key issues for minimising the potentially negative effects of JIT on people. Hinterhuber and Popp [189], provide a checklist of strategic leadership competences.

Kochhar and McGarrie [7] found that successful implementation of control systems requires that a company has the right attitude to change. The pace of change should not be such as to cause a variety of longer-term problems.

Brown [190] suggests that one of the principle reasons why MRP and other large and technologically sophisticated systems fail, is that organizations simply underestimate the extent to which they have to change in order to accommodate their new purchase.

Willis and Suter [98] approach the management of change with a 5 phase overlap of the M's of mindset, motion, movement, materials and momentum. Burns, Turnipseed and Riggs [78], on the other hand, suggest a classical approach to the management of change involved when implementing MRP II systems, which is to involve as many of the affected workers as possible in the planning and implementation stages. White and Flores [191] address the importance of goal setting in the production or operations environment. The authors believe MRP has some unique characteristics which make the system a prime candidate for goal setting. Smith and Tranfield [75] highlight the importance of attitude change as well as understanding, when implementing MRP II. Galvin [192] stresses that management support without understanding is a liability.

The study by Kochhar and McGarrie [7] found that top management must be committed to the introduction of a new manufacturing control system, providing good support during implementation, including negotiations with the unions. This confirms the extensive existing literature on the importance of top management commitment, for example, Heard [138], Hartley [193] and Hall [150]. Vora, Saraph, and Petersen, [65] in studying JIT implementation practice, found that top management commitment was only marginally followed. A Critical Success Factor (CSF) for MRP II implementation is executive vision and plan, with strategy and tasks clearly defined, documented, communicated and discussed, according to Schlussel [91].

Management support and commitment to a JIT program by top executives helps to secure individual participation, as reported by Helms [194]. The most important task when implementing JIT, according to Keller, Kazazi and Carruthers [86] is the engendering of a universal culture in a company with regard to JIT at all levels from chairman down to office worker.

Resistance to change and a natural human inclination towards keeping one's own private little database make it most difficult to implement an MRP system successfully, as suggested by Maes and Van Wassenhove [26].

Education and Training

Kochhar and McGarrie [7] show that a high level of formal ***education and training*** is critical to the successful implementation and subsequent operation of a new manufacturing control system. Stewart [195] discusses the use of Problem identification meetings, originally designed as an approach to the training and development of supervisors, adopting an Organisational Development methodology as an alternative to the common skills approach. A number of stages are involved. Torkzadeh and Sharma [12] highlight the need for education seminars to be company specific. Some of the seminars offered at educational institutions may not be suitable for smaller companies. Most small companies buy the MRP package, but for financial reasons, are hesitant to invest in such training programs. Newman and Kirk [196], point out that rapid growth in a company, implies a steady influx of new employees and, consequently the need to train them in conjunction with any implementation. According to Millard [197], there is mounting evidence that the most important training needs are not specifically related to MRP. Three subjects where training will provide immeasurable assistance in implementation: i) Problem-solving, ii) System design, iii) Documentation. The same author differentiates between generic education and application training and outlines typical MRP training problems: Schlussel [91] highlights the need for Project team education .

Organisational Structures

Crittenden [198] outlines mechanisms for improving ***interfunctional coordination***, especially between manufacturing and marketing. On the other hand, Powers, Sterling, and Wolter [199] note the need for top management to maintain a constructive amount of tension between manufacturing and marketing functions while retaining sufficient autonomy to allow for a balanced pursuit of company goals.

3.2.7 Quality Issues

Few references are made to quality issues within the existing literature, therefore no subsystems have been allocated to this section of the review.

Kochhar and McGarrie [7] identify the fact that all of the control functions under consideration in their study, are detrimentally affected by the existence of ***low yield and high rework***. Pull control, in particular, is not suited when "black-art" processes are present, or when there is a high level of rework.

It is made clear by Dale, Shaw and Owen [200], that most organisations face problems in the implementation and use of Statistical Process Control, ***SPC,*** and that most of the difficulties are self-inflicted. Schonberger [147] argues that SPC is not much use in a job shop because job order quantities are usually too small to draw samples from.

An alternative to following rigid variable sampling plans, includes developing ***special templates*** capable of checking multiple characteristics concurrently or using a go/no-go gauge rather than a tool that requires interpretation, according to Hannah [5].

Chan, Samson and Sohal [92] describe ***Poka yoke*** as "Error proof" design of equipment, tools, jigs to ensure no error is made by the workers.

Conti and Warner [180] outline the use of Kaizen, and Schniederjans [201] introduces the Productivity Cycling Process, which is a ***continuous improvement*** program. In a similar vain, Ajala [202], highlights categories of wasteful practices, and McNair [188] depicts the many sources of waste that are bundled into capacity management in most companies:

3.2.8. Supplier Relations Issues

The literature on supplier relations issues can be categorised under two subsystems, namely; supply strategies and sourcing techniques. The characteristics identified within the literature will be presented under each of these subsystem headings.

Supply Strategies

A high number of ***bought-out parts*** highlights the need for MRP, inventory control and purchasing, according to Kochhar and McGarrie [7].

Kochhar and McGarrie [7] also discuss the uncertainty arising when suppliers do not ***deliver on time***, with the consequent detrimental effect on the use of all control functions. Pull control is very difficult to operate unless the number of bought-out parts is kept to a minimum or extensive buffering is maintained. MRP becomes very nervous, and the uncertainty about material availability also affects the functions of purchasing, capacity planning and shopfloor control. Lee and Billington [100] do not understate the significance of on time delivery, but contend that not enough attention is paid to providing customers with timely and accurate updates on the status of late orders.

Sourcing Techniques

The trend continues towards fewer, larger and more talented suppliers as the sole source of supply for component systems, as highlighted by Turnbull, Delbridge, Oliver and Wilkinson [203]. Only a select ***few suppliers*** are likely to survive as preferred suppliers in the 1990's.

According to Lee and Billington [100], Supply Chain Managers must understand the sources of uncertainty, and the magnitude of their impact. It is surprising that many supply chains do not document and track these variables. Some companies respond well to uncertainties but fail to work on ways to eliminate them.

According to Romero [204], there is a lack of understanding of 2 basic foundations of JIT, namely; the definition of a clear strategy of the company, and the role of supply management strategy within the supply chain.

3.2.9 Customer Relations Issues

Few references are made to customer relations issues within the existing literature, therefore no subsystems have been allocated to this section of the review.

Kochhar and McGarrie [7] found that a regular demand pattern is essential for the smooth operation of cellular manufacturing systems, and hence the use of pull type of control system. Irregular demand patterns result in nervousness in the operation of all types of manufacturing control systems.

These same authors also found that uncertainty with regard to the length of product life cycles affects the choice and suitability of pull control. Uncertainty as to the length of product life cycles leads to changeover flexibility, according to Gerwin [153], which is the ability of a process to deal with additions to and subtractions from the mix over time.

Kochhar and McGarrie [7] also produce some results on the number of strangers, with a large number increasing the shopfloor and capacity problems, and thus indicates the need for a degree of sophistication in these functions. On the other hand, a small number of strangers and thus a large number of repeaters and runners indicate the suitability of a pull type of control system. This supports the view of Parnaby [205].

In a manufacturing environment where customised products are the norm, the popular approaches to production planning and control such as MRP and CIM which have their roots in repetitive manufacturing systems, may have limited applicability, according to Jackson and Browne [206].

3.3. Conclusions

The review of the existing literature on production planning and control has highlighted a large number of characteristics which can impact the selection, implementation and improvement of such systems. These characteristics will from the backbone of the framework to be developed in chapter 4.

Chapter 4

Generation of the Framework

4.1. Requirements of the Framework

The literature categorisation process in chapter 3 permitted the identification of a large number of characteristics which affect either the selection, implementation or improvement of a production planning and control system. The literature review also led to the categorisation of these characteristics, in a Supply Chain manner. The objective of this chapter is to design a framework for the selection and implementation of production planning and control systems in small manufacturing firms, based on these literature categories. Therefore, the content of the framework has to a large extent already been documented in chapter 3. This chapter therefore concentrates on the process flow of the framework.

No such framework, devoted to small manufacturing companies appears in the literature, but there are a number of requirements to be outlined before the design of such a framework:

i) The intention is to make the framework dynamic, and facilitate continuous improvements within companies. Therefore, any framework developed, will need to include a feedback loop capability.

ii) The framework has to include some measure of objectivity for each of the characteristics included.

iii) It has to be assumed that not all of the characteristics will be relevant in every individual company. Therefore, the framework has to allow the user to be selective when undertaking a study. Consequently, the framework should be available for use in a modular fashion.

Therefore, for example, if a company wishes to improve the introduction of new products, then this should be facilitated, although at the same time, highlighting the dangers associated with the loss of a supply chain viewpoint.

iv) The framework has to enable in-depth analysis, given the propensity to follow a case study rather than survey methodology (to be discussed in chapter 5).

v) As suggested by the existing literature, [8], [45], [47], [76] and [77], most companies still need a computer-based production management system, therefore this framework should contain a mechanism for selecting and implementing software solutions. However, it is not the aim of this study to replicate the approach taken by computer vendors when implementing new production planning and control systems, but to enhance any solution by ensuring that the small company has exhausted other improvements to the existing system, or by carrying out the necessary pre-implementation tasks for the implementation of a new computer system.

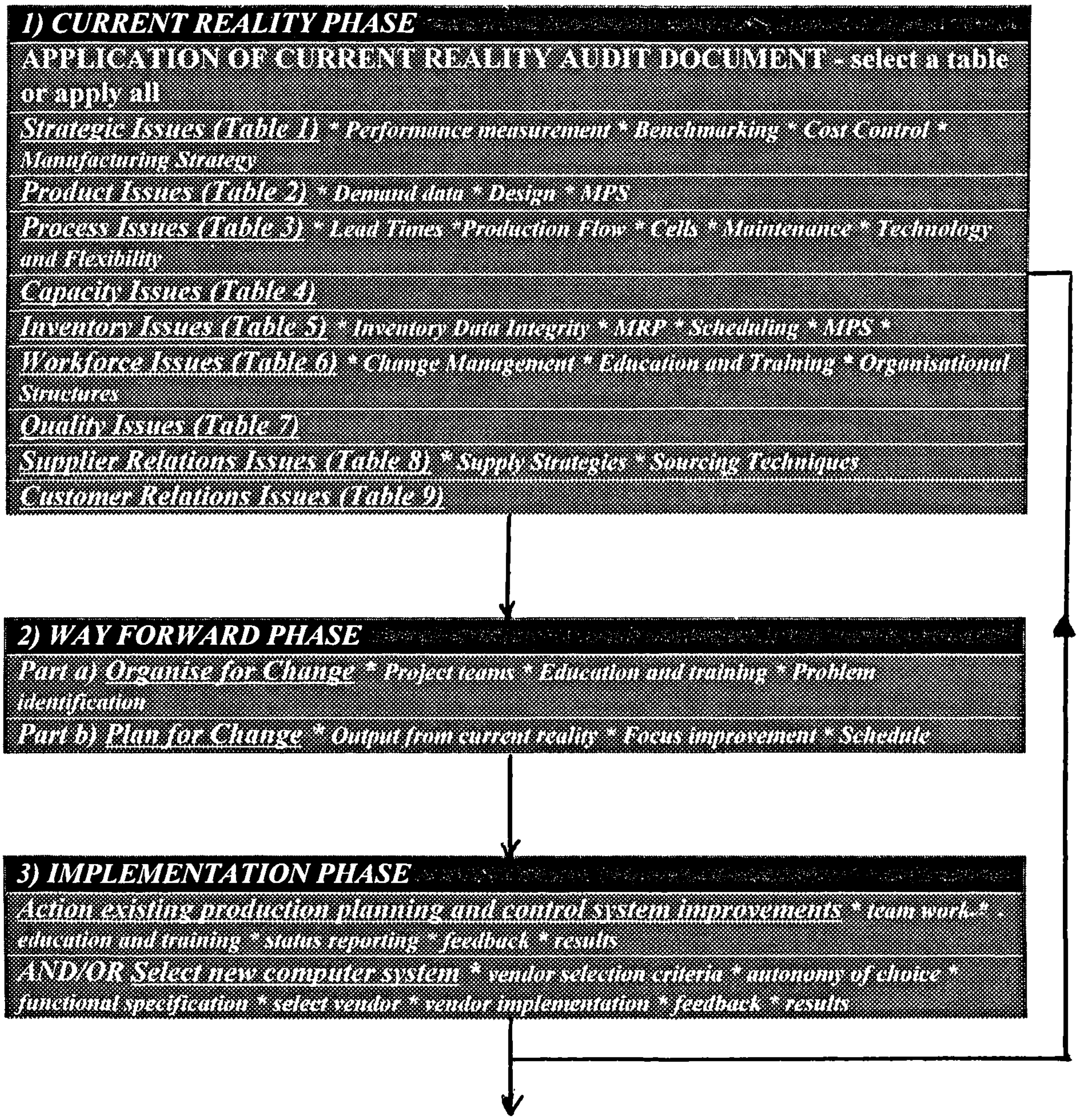
vi) The majority of the existing literature on production planning and control focuses on large company applications. Consequently, many of the characteristics and therefore solutions derived from the framework, will be of best practice in larger companies. However, this should not prevent small companies from investigating the application of such practices in their environment, if considering the resource implications in full. An additional benefit here is the increased awareness that the company will gain of the operations and new techniques being applied by industry leaders, perhaps in their supply chain. A key requirement of such a framework, is that the company under consideration are prepared to examine the underlying assumptions behind their relationships with both customers and suppliers.

vii) Successful implementations of new production planning and control systems are user-led [12], [195], [207]. It is intended that this framework facilitates a user-led approach to the focusing of improvement via education and training of the workforce, including the shopfloor personnel.

4.2. Design of the Framework

The framework is shown in figure 4.1.

Figure 4.1. Framework for the Selection and Implementation of Production Planning and Control Systems



Each of the phases in the framework shall now be described in turn.

4.2.1 Current Reality Phase

The Current Reality Phase begins with a comprehensive analysis of the existing production planning and control system within the company. This is based on the Current Reality Audit Document reproduced in full in appendix 3. This document emerged from the comprehensive literature review of chapter 3, which provided the rationale for including each characteristic in the framework. An example of an extract from the rationale for inclusion document is provided in appendix 4. Thus, each characteristic in the document has an either an impact on the selection, implementation or improvement of production planning and control systems. The characteristics are categorised as per the analysis of the literature, although there are more questions and sub-characteristics to enable operation of the Likert Scale, and to provide background material on a particular topic.

The Current Reality Audit Document is completed by a number of top managers from the organisation under study. The categorisation of the literature and the subsequent design of the framework facilitate a number of different functional managers reaching a consensus decision on the scoring scale for each question posed. In addition, the author will also come to some conclusions regarding the score for the characteristics under study at that time.

Measurability is provided by the Likert Scale, from a low degree to a high degree. Thus, the objective is to focus on the questions which are answered in the left- hand side of the framework, as it is these characteristics which will highlight the need for change in the existing production planning and control system. Miller [208] provides a comprehensive analysis of evaluation research and organisational effectiveness. Effectiveness is defined by Miller as:

'........the degree to which a social system achieves its goals' (p376).

A profile of Organisational Characteristics is provided by Miller, which is a set of rating scales used in interviewing managers in an organisation. They are applicable for any group of supervisory heads in any organisation. The form can be used to measure the management system of any unit within an organisation, as well as that of the total organisation. Likert's Profile of Organisational Characteristics [209] is a well-tested set of rating scales that may be applied to probe the motivating facet of the relevant organisational variables. The benefit of this type of scale is that it provides the researcher with general criteria for assessment of organisational effectiveness. A yardstick of performance is thus provided for each of the characteristics by company. Burns, Turnipseed and Riggs [78] provide an example of the use of Likert Scales in MRP implementation research.

For consistency purposes, and for ease of qualitative data analysis [210], each of the characteristics is framed in a question, to enable all low scores to be immediately identified as being a potential hindrance to the selection, implementation and improvement, or indeed as potential improvement in itself. Thus, all high degree scores provide evidence of potentially good practice in production planning and control, or highlight that this characteristic is unlikely to provide a hindrance to changing the production planning and control system. The use of background characteristics and questions allow further details to be highlighted in certain topics.

When used, as in this study, as a tool for case study analysis, the benefit of the design becomes apparent. The researcher can probe the interviewee for quantitative answers to the question, take detailed notes in the spaces provided or merely indicate on the Likert Scale what the degree of success or existence exists.

Slack and Correa [56] discuss the problem of putting quantitative values on measures of flexibility. It is assumed in this framework, that the Likert Scale is a suitable method of providing some sort of benchmark for the characteristics under study. Where possible, quantitative data is obtained and used for analysis. The influence of company-specific data is likely to be strong.

If the framework was to be used in a survey design, for example, in a postal mode, then the lack of detailed quantitative answers may provide a problem. However, given the length and complexity of the document, it is unlikely that many replies would be received, unless used in a modular basis.

4.2.2 Way Forward Phase

The output from the Current Reality Phase, namely the audit document, provides a direct input into the second phase of the framework, the Way Forward. This second phase operates in two stages. The first stage (a) is the organisation for change, and the second stage (b), is the plan for change.

To achieve a user-led framework, it is intended that the company under study organise themselves for the change process. As can be seen from the framework diagram, this will involve the formation of a steering committee and a project team if resources allow. Alternatively, in a very small company, or in a very lean organisation, one or two top managers, perhaps including the Managing Director will provide the necessary stimulus for any suggested change in production planning and control. Education and training sessions can be provided by the researcher to facilitate problem identification exercises to complement the study of the audit document, which is the first task of the newly formed change organization.

In stage two, this document is likely to highlight a considerable number of ways that production planning and control can be improved. The number of low scores on the audit document will outline the extent of the problems within the company, and consequently the need for improvement in certain areas. The project team will meet with the researcher to focus on a certain number of improvements to realise maximum benefits. For example, if the framework highlights the need for an improvement in the purchasing effectiveness, then ways of improving this functionality are examined from the Rationale for Inclusion in the framework, and a consensus decision is arrived at. Alternatively, there may be a large number of problems in most areas of the company and tough decisions will need to be made with regard to the focus of attention.

The final output of this phase is thus to provide a schedule or plan of improvement of production planning and control system. This may be a relatively straight forward improvement to a certain function, or the implementation of a new computer system. Thus, the decision is now made by the top management in the company regarding the extent of changes necessary. The decision made here will influence the phase to be undertaken in the Implementation phase.

4.2.3 Implementation Phase

The third phase involves the team working on the improvements highlighted in phase two. Therefore, two possibilities exist at this stage. The framework diagram indicates two choices. If improvements are only to be made to the existing production planning and control system, then part one is undertaken. However, it is also possible that a new computerised production planning and control, system will be implemented, in which case part two of phase three will be undertaken. Both of these parts must be a tightly controlled, with status reporting at regular intervals, and feedback and results to top management. Education and training can also be provided to aid motivation of the workforce by keeping them aware of the changes taking place.

If the implementation phase involves a new system purchase, then vendor selection criteria have to be derived from within the company, complemented by a functional specification document. The vendor will then provide an implementation plan with continual feedback to the management team. However, the work of the project team should run in tandem with the work of the software vendor. If the company is part of a larger group, then the autonomy of choice must be established. It may be the case that the Group headquarters will wish to introduce a computer system compatible with the rest of the organization.

4.2.4 Feedback Loop to Current Reality Phase

It is intended that the framework be for continual improvement purposes, therefore after the results of phase three, the process should continue with a re-examination of the Current Reality Audit Document, leading to the focus on new improvements in the production planning and control system. However, it is acknowledged that certain companies may wish to end the application of the framework at this stage.

The application and validation of the framework will be analysed and presented in Chapter 6.

Chapter 5

Methodology for Implementation of the Framework

5.1. Introduction

This chapter will evaluate the potential research methods which could have been used, and identify the reasons for selecting case study design.

5.2. Selection

According to Taylor and Bogdan [211] 'qualitative methodology' refers in the broadest sense to research that produces descriptive data: people's own written or spoken words and observable behaviour.

Yin [212] highlights 3 conditions which really distinguish one research methodology from another: the type of research question posed, the extent of control an investigator has over actual behavioural events, and, the degree of focus on contemporary as opposed to historical events. Based on these 3 characteristics, a distinction between experiments, surveys, history and case studies is made.

Yin further suggests that the case study strategy is better for research questions which are more explanatory such as 'why and 'how'. These questions deal with operational links which usually have to be traced over time. They are different from survey questions which are more oriented to measure frequencies or incidences. Thus, from the initial literature work in chapter 2, qualitative research looks a clear cut decision.

Bryman [213] proposes that:

" .. the aim of the case study is not to infer findings from a sample to a population, but to engender patterns and linkages of theoretical importance."

Again, in this study, that would seem to infer an in-depth approach.

Marshall and Rossman [214] conclude that the strengths of qualitative studies should be demonstrated for research that is exploratory or descriptive, and that stresses the importance of context, setting, and the subjects' frame of reference.

Taylor and Bogdan [211] suggest that qualitative research is inductive, and that researchers develop concepts, insights and understanding from patterns in the data, rather that collecting data to assess preconceived models, hypothesizes or theories.

Thus, the existing research methodology literature points to the use of the case study technique for the validation of the framework in this study. A powerful attraction for the case study technique, is that it allows data to be typically collected over a sustained period. Therefore, it is possible to go far beyond 'snapshots' of company situations.

5.3. Data collection

Silverman [215] presents a variety of qualitative data collection methods, but provide a summary of the four major ones; namely, observation, analysing texts and documents, interviews, recording and transcribing. The author surmises that these methods are often combined, and that each method can be used in either qualitative or quantitative research studies.

Marshall and Rossman [214] rule data collection down to 2 fundamental techniques; observation and in-depth interviewing. These authors provide detailed discussions of these two techniques. Observation entails the systematic description of events, behaviours and artefacts in the social setting chosen for the study. A participant observation is a special form of observation and demands first hand involvement in the social world chosen for the study. In-depth interviewing is much more like conversations than formal, structured interviews.

However, Marshall and Rossman also highlight the limitations of these techniques: must involve personal interaction; cooperation is essential; may not be willing to share all information that is needed with the interviewer; may not ask appropriate questions because of lack of expertise or familiarity with technical jargon; answers may not be properly comprehended by the interviewer; when interviews are used alone, distortions in data are more likely, as interviewers may interject personal biases; volumes of data may be obtained through interviewing, but such data may be difficult to manipulate.

Burgess [216] discusses four possible research identities within participant observation: the complete participant, who operates covertly, concealing any intention to observe the setting; the participant-as-observer, who forms relationships and participates in activities but makes no secret of an intention to observe events; the observer-as-participant who maintains only superficial contacts with the people being studied; the complete observer, who merely stands back and 'eavesdrops' on the proceedings.

Jorgensen [217] maintains that the method is likely to prove most successful when: the researcher is confident of obtaining reasonable access; the research problem is observable and capable of being addresses by qualitative data; and the research setting is sufficiently limited in size and location for it to be effectively observed.

Bryman [213] describes action research as an approach where the researcher is involved in conjunction with the members of an organization in dealing with a problem which is recognized as such. It is usually used in applied social science and it is oriented to 'solve a problem' in the organization. The main criticism, according to Bryman, is that it is too close to consultancy and the researcher looses the detachment, by getting too involved in the organizational environment.

Thus, the use of in-depth interviewing and preferably action research and participant observation, are ideal techniques for the validation of the framework developed in this study.

5.4. Data Analysis

The conceptual framework developed through the literature review suggests possible categories or conceptual schemes for data analysis. Jorgensen [217] discusses the data analysis possibilities when undertaking qualitative research. He suggest that it is useful to include a hypothesized model or an outline of possible observation and coding categories, which can be developed from a pilot study or from a literature review. The analysis of qualitative data is dialectical, where data are disassembled into elements and components, these materials being examined for patterns and relationships, sometimes in connection to ideas derived from literature, existing theories, or hunches that have emerged during fieldwork or perhaps simply common-sense suspicions. This is the approach that will be taken in the validation of the framework in this study.

Jorgensen [217] goes on to further describe the reassembling of data, providing an interpretation or explanation of a question or particular problem where the synthesis is then evaluated and critically examined. Miles and Huberman [214] outline the components of data analysis; data reduction; data display; conclusion drawing and verification.

5.5. Defence of Qualitative Methodology

Lincoln and Guba [218] defend the validity of qualitative research:

> "1- How truthful are the particular findings of the study? By what criteria can we judge them?
>
> 2 - How applicable are these findings to another setting or group of people?
>
> 3 - How can we reasonably sure that the findings would be replicated if the study were conducted with the same participants in the same context?
>
> 4 - How can we be sure that the findings are reflective of the subjects and the inquiry itself rather than the products of the researcher's biases or prejudices?"

Yin [212] also considers lack of rigour, the lack of a basis for scientific generalizations, and the length of time case studies take.

Moser and Kalton [219] identify 4 problems associated with informal interviewing:

> " 1 -interviewer skill - knowledge of the subject, intelligence, understanding and tact.
> 2 - interviewer bias, intruding on the interview process.
> 3 - depth of the interview - indulgence in inordinate detail not relevant to the propositions. A semi-structured interview format was adopted, with an agenda sheet to guide the progress in the hope of minimizing this problem.
> 4 - analysis the difficulty of summarizing and quantifying the material. Descriptive, non-quantified interviews do not lend themselves to statistical analysis easily."

The previously mentioned authors provide a checklist of points to take into account when undertaking case study analysis.

Having outlined the reason for the choice of case study design and having gone through the data collection techniques, the framework will be now be validated and tested in chapter 6.

Chapter 6

The Field Work

6.1 Introduction

Having developed the framework from the literature, it is now intended to validate the framework by trying to operationalise it in a number of manufacturing sites. The intention was to visit as many small companies as possible to validate the document. Given constraints of time, logistics and contacts, the number of sites was limited to 10. However, in one of the sites, company A, the author was present for a large part of the working week in the role of advisor to the company. This was invaluable in that the perfect opportunity arose to test the framework. In addition, the author was heavily involved, but to a lesser extent, with company B. These two case studies, were very time consuming but very beneficial in that they allowed an insight into the workings of the human dimension of production planning and control systems.

Although Marshall and Rossman [214] consider the factors involved in site and sample selection, the case studies in this study were, in the main, from personal contacts. Marshall and Rossman consider a site ideal when:

> "1 - entry is possible
> 2- there is a high probability that a rich mix of many of the processes, people, programs, interactions and/or structures that may be part of the research question will be present.
> 3 - the researcher can devise an appropriate role to maintain continuity of presence for as long as necessary
> 4 - data quality and credibility of the study are reasonably assured by avoiding poor sampling decisions.'

Table 6.1., summarises the background characteristics of each company.

	No. of employees	Products and Nature of Business	Ownership of the Company	Current production planning and control system
Company A	55	**Specialist manufacture and assembly for road and rail industry**	**Part of a group of small engineering companies (U.K.)**	**MRP II**
Company B	300	**Automotive component supplier and assembler**	**American Group**	**Hybrid, MRP II and JIT flowlines**
Company C	45	**Design and assembly of waveguide lasers**	**Management buy-out (U.K.)**	**Mainframe MRPII**
Company D	60	**Design and manufacture of high technology products**	**Management buy-out (U.K.)**	**Mainframe MRPII**
Company E	24	**Subcontract precision machining for high technology industries**	**Private (U.K.)**	**Manual**
Company F	75	**Microwave products for military and commercial customers**	**American parent**	**MRP II**
Company G	140	**Design, manufacture and assembly of high technology products for comms. industry**	**American parent**	**MRP II**
Company H	80	**Design, manufacture and assembly of retail petroleum services**	**American group**	**MRP II**
Company I	65	**Assembly of microwave cable**	**American group**	**MRP II**
Company J	150	**Fittings for plumbing and heating industry**	**Group (U.K.)**	**ROP**

With reference to the number of employees in each company, then all are small-medium enterprises (SME's) according to the European Union definition of a distinct business entity with no more than 500 employees [42].

The influence of the Group Headquarters is indicated throughout the company cases at relevant points, but all companies are distinct business entities. Indeed, within some of the companies, the situation is complicated by the existence of a number of different business units. The Cambridge Small Business Research Centre [43] definitions prove useful in this study, namely;

Micro: less than 10 employees.
Small: 10-99 employees.
Medium: 100-199 employees.
Larger: 200-499 employees.

Therefore, in this study, seven out of the ten companies can be classified as small, and two as medium sized. The exception to the rule is company B, who are a larger SME. However, the benefit of applying the framework to the study of company B, lies in the fact that they are a first-tier supplier in the automotive industry, and as such, offer the analysis of some best practices in Supply Chain Management.

Company C and Company D were both management buy-outs from the same high technology company, and also offer comparative material. Company E is a major supplier of Company D, thus allowing the study of a small part of that supply chain. Six of the ten companies operate in a high technology product environment. Eight of the companies have a MRP II system in place.

Initial contact with the company did not involve the Current Reality Audit Document, but instead, a general questionnaire was developed by the author, for the purpose of talking in general terms about a particular subject without worrying about objectivity and measurability. This broad based questionnaire is shown in appendix 5.

6.2 Discussion of the Individual Cases

Ten companies participated in the study, with **Company A** being the action research case, where a new computer-based production planning and control system was selected and implemented during a two and a half year period. After discussing, in some detail, the application of the framework within Company A, **Company B** will be considered, which is also a company the author has strong links with. Due to space and practical problems, the other eight companies will introduced in a briefer format, with the main conclusions from the Current Reality Phase presented and discussed. As the framework is intended, in the main, to flag up problems to be solved, or to indicate a potential hindrance to a any new implementation, then it is acknowledged that the companies are presented in a rather negative light. .

6.2.1 Company A

Background

The company design, manufacture and assemble, specialist products for the road and rail industries. The business has three sides to it, namely; normal trading, wire and contract. This study applies to all sides of the business, differences in approach and requirements being highlighted where appropriate.

Current Reality Phase

The Current Reality Audit Document enabled the author to build a very comprehensive picture of the existing practices within the company over a period of weeks. The results of the application of the Current Reality Document to company A, are presented in appendix 6. The tables relate to the main topic areas developed in the framework diagram. The numbers after the * scoring symbol, are related to the Way Forward Phase of the process. The following section provides a summary of the main concerns raised by the Current Reality Phase. In particular, the emphasis of the analysis will be on the characteristics which show the lowest score.

Strategic Issues (Table 1)

Measures of performance were to all intents and purposes, absent within the company. Appendix 6 indicates that all Measures of Performance scored low on the Current Reality Audit Document. This made objectivity extremely difficult within the exercise.

The next section of low scores were obtained in the Cost Control subsection of the document. In particular, the Accounts department were being continually frustrated by the lack of up to date costing information. Indeed, only material values were on the existing computer. They also required better sales statistics, for example, on how much had a particular customer bought, and what the gross margins were being made.

The lowest score possible was arrived at for all factors in the Manufacturing Strategy subsection of the Current Reality Document. The Manufacturing Strategy Process was controlled by the Managing Director, who enabled each functional manager to prepare a brief statement, which he himself then developed. Therefore, this appeared to demotivate the management team.

Product Issues (Table 2)

In the Demand Data subsection of Table 2, the regularity of the demand pattern, and the inability of the company to cope with customer revisions, both give cause for concern. These issues were also highlighted later in the Customer Relations table, and shall be discussed at that point.

As can be seen from table two in appendix 6, the Design subsection raises a large number of concerns. Some of these issues are now discussed.

In both the lighting and wire side of the business, within the previous year, the company had added six brand new products to their range. The number of new products with variations, took this figure up to twenty five new products in total. The 6 brand new products, needed process changes, being new contracts, and consequently needed a whole set of new components. The existing computer-based production planning and control system, was woefully inadequate in dealing with this sort of pressure point. New assemblies had to be built from scratch.

In the lighting section, with regards for identifying common parts at the design stage, this was done on an informal basis, if the proposed new product was a variation on the existing theme. For a brand new product, there was no way of listing standard reflectors (an integral part of the lighting product) on the existing system. Of a brand new design, only screws and fasteners tended to be in common, unless it is reassembled as an existing unit. The company could not really go the commonality route.

New products tend to be totally different all the time for the company's main rail carriage assembly customer, due to the OEM's customer requirements. This customer accounted for approximately 70% of the company's total business. The Wire side of the business had a fairly high level of commonality of parts, and thus, a simpler planning and control requirement. The company did not appear to have the highly responsive internal logistics and procedures necessary to cope with revisions in customer demands.

Duplication of B.O.M.'s was a problem within the Engineering Department. Indeed, B.O.M.'s for normal trading were poor. The company still did not have drawings for every product manufactured, with inaccurate drawings leading to inaccurate B.O.M's.

Process Issues (Table 3)

The Lead Time subsection indicates that the company is struggling to deliver products to customers on time. In particular, the lighting side of the business were struggling to get their orders shipped out on time. At the time of the Current Reality Audit, the sales department had to ration out the products available, with those customers who shouted loudest increasing their chance of products arriving on time. There was consequently a 6-8 week lead time for those standard road products, which should have been available on an ex-stock basis. On rail products, this was 10-14 weeks, and even then the company was not hitting the customer on time

Capacity Issues (Table 4)

Although scoring fairly lowly on the Capacity Issues table, the company did not have any lowest level scores in this area.

Inventory Issues (Table 5)

According to table 5 in appendix 6, company A had a large number of significant problems in the area of inventory data integrity area. A number of these concerns are now raised.

Inventory data was only accurate for one to two days following annual stocktakes. The Managing Director had no confidence in this data a week after the stocktake. Inventory controls were very inadequate through the organisation. The sales information was very good, because it was managed by the sales manager, who knew the existing system and the ways around it. The information was of good quality, but wasn't available quickly enough. Within normal trading, there were no well-documented procedures. Although there wasn't a customer requirement for full material traceability, this was expected to change in the near future.

With regard to the MRP subsection of table 5, the company did not have anybody really experienced with the workings of a MRP-type production planning and control system. The existing system was very inflexible with regards to report generation. For example, a request for the top ten customers by volume and by value required a number of printouts. The Master Production Scheduling table indicates the confusion surrounding the ownership of the MPS process, between sales and manufacturing.

Workforce Issues (Table 6)

Major problems existed in company A with regards to workforce Issues. The Change Management subsystem indicates potential difficulties with any future changes. The Managing Director of Company A had a very positive attitude to change. However, the existing managers in the company seemed reluctance to change. Managers were very much day-to-day control people. An example of this could be seen with regards to the proposed new computer system. If the Managing Director had not questioned the quality of the information coming out of the current system, both in speed and effectiveness, he believed the managers would have been quite happy to keep the system going until it finally broke down, leading to potentially disastrous problems

The company didn't have a structured or consultancy approach to the management of change. However, the company did actively collect ideas although perhaps not encouraging people to the extent they ought to have done.

Within the Education and Training subsystem, the company didn't actively plan, manage and develop, an educational policy. They did however, encourage people to go for further education, if matching the needs of the company.

The Organisational Structure subsystem indicates that with regard to interdepartmental co-ordination, problems exist. The relationship between engineering and sales was strong, but, however, the co-ordination between sales and manufacturing could best be described as fraught.

This appeared to be down to the personality of the Materials Manager, who had been allowed to develop his role beyond his abilities, and assumed responsibility for other managers. Accountability was poor within the existing system, with too many allowances being made because of the current computer system. In a small company, the system is going to impinge on all areas of the company, therefore indicating the need for someone to provide a real overview. An integrated computerised production planning and control system would allow data integration to be facilitated.

Quality Issues (Table 7)

Considerably quality problems existed on the shop floor in the lighting section. Non-conformance was running at 2-3% by value, although this figure was distorted by warrants return section which had been added to this figure. However, it was suspected that this figure was higher given the lack of control and feedback on quality problems.

Supplier Relations Issues (Table 8)

Considerable problems exist in the Supplier Relations Issues, in both Supply Strategies and Sourcing Techniques. The company had a very limited machine shop, with most components being purchased, indeed less than 10% of the components being manufactured in-house. The lighting side of the business had 4,500 different components on the system, of which 3000 were active. Being almost an assemble-only company, there were a large number of purchasing and stock transactions carried out over a period of time. The existence, therefore, of 1,500 inactive component files indicates the extent to which the current system had fallen into disrepair.

Both the lighting and wire side of the business suffered from poor delivery performance from suppliers. It was thought that suppliers delivered approximately 70-80% on time. The company was basically supplier driven though, waiting on average, 6 weeks for any given component.

Therefore the lighting side of the business was most definitely supplier driven, and not customer driven. Perhaps fortunately, the company had been through a quiet period, and their inefficiencies had been hidden by the market situation. The existing computer system was certainly not tailored to counteract this situation. The wire side of the company also had to deal with components being purchased from as far away as Taiwan and the US, and consequently had to stock to service the customer on time

The quality of components received from suppliers was said to be good, at 2-3% in rejects. However, this did not meet the high standards expected under JIT production, where a company should be aiming for parts per million measurement.

Customer Relations Issues (Table 9)

On the wire side of the business, a significant seasonal demand pattern existed, with end products selling from September through to March. Thus, the peak months for manufacture were November, December, January and February, producing approximately 130,000 ignition leads per month in this period (approximately 26,000 sets of leads). Low production months were April, May, June, July, and August, producing approximately 50,000-60,000 leads. Level schedules tended to be produced to counteract this problem, building up stock in low production periods.

The Sales force worked from the computer screen all of the time. With no sales force out in the field, there was therefore a complete reliance on direct phone contact with the customer. The department worked to an internal reference number. The existing computer system worked from the oldest number on record, whereas a customer, if phoning up, was invariably likely to be talking about the most recent reference number.

Way Forward Phase

The Current Reality Audit Document therefore provided the company with a detailed picture of the problems they faced. The Framework developed from the literature was designed to be user led. Therefore, the first action in the Way Forward Phase was to organise for change. A project team and steering committee was formed at the request of the author of this study, and backed up by the Managing Director of the company. The first meeting of both team and committee was held jointly and involved dissection of the Current Reality Audit Document to highlight potential actions to move the process into phase 3, that of action or implementation. The Steering Committee consisted of three people; the author of this study, The Managing Director and the Engineering Manager. The project team consisted of 6 managers and supervisors below the top management level, and generally including a representative from all of the main functions within the company.

As described in the First Phase, the main problems shining through were the lack of confidence in the existing production planning and control system, and also the lack of confidence in the suppliers to the company. A strong consensus emerged at the first meeting that the possibility of purchasing a new computerised production planning and control system be looked into. In the meantime, a list of possible actions was shortlisted by the project team for investigation with a view to carrying out immediate improvement flagged up by the Audit Document.

The potential action points derived from the first phase are outlined below. The action points are linked to the Current Reality Audit Document by means of the numbers below. The list contains only those points scoring the lowest in the Audit Document. It should also be recognised that this list of 50 potential actions points was arrived at by consensus of the Steering Committee.

DISCIPLINES AND PROCEDURES

1) No/little production procedures. These should be fully documented. For example, "how production should proceed?". These procedures should not be too difficult to follow.

2) No adherence to manuals (new product books), even though section leaders sign for them. These manuals are apparently very rarely used.

3) Lack of familiarity with BS 5750, with no encouragement to do so, and no commitment towards the standard.

4) When suppliers are changed, the engineering department are not always informed. This causes problems with control documentation. Change request documentation does not appear to be used at all times. Potential problems are the use of suppliers who are not quality approved.

5) No control over rework.

6) No respect for drawings, which are often lost.

7) Month-end procedures are not always followed.

8) Lack of Goods Inwards disciplines. People often seem to be diverted to other jobs. In addition, the definition of booked-in seems to be the writing of a Goods Received Note, whereas goods should be booked in and useable. This would seem to indicate a failure in the existing procedures, with a move towards inspection before GRNís, likely to be beneficial..

INVENTORY ACCURACY

9) Multi-location stores at present.

11) A general lack of discipline and procedures.

12) No education and training of stockroom personnel.

13) No accountability for inventory accuracy.

14) Reliance on quarterly stocktakes, and not cycle counting. The use of control group-count before the implementation of a full-blown system would be beneficial.

15) No root cause analysis undertaken.

16) Little preparation is carried out for the stocktaking.

17) The existence of a "well-stocked" quarantine area.

18) No ABC inventory analysis.

19) The use of a mixture of significant and non-significant part numbers.

20) Poor housekeeping in general.

21) No documented inventory accuracy policy (to be made visible to all employees).

SUPPLIER PERFORMANCE

22) No real control over supplier delivery performance. This results in inadequate lead times on the system. No account seems to be taken of supplier holidays.

23) Supplier quality performance also seems to be a problem

24) Little move towards supplier integration and development.

EDUCATION AND TRAINING

25) No on-going training/skills matrix. Although the company has an advantage of being in the low skill assembly-type environment, there does appear to be too much "movement" on the shop floor. That is, if a good team emerges, key people appear to be pulled-off, and placed elsewhere. This seems to have resulted in a lack of team spirit on the shop floor.

26) Selection of supervision appears to be a matter of concern on the shop floor.

27)Job definitions/specifications also seem to be a matter of concern on the shop floor, especially for people operating in dual roles, such as production and stores.

28) Line leaders appear to be measured on output, which can cause difficulties, given the differences in the work content of assemblies.

COMMUNICATION

29) Inaccurate information passed on to sales from the shop floor. This would appear to stem from a lack of accurate due dates when SRNs are issued.

30) Shop floor complain that inadequate warning is given of SRNís to be released. Consequently jobs can be released when required parts are unavailable.

31) There are no current work standards for the shop floor operations

LONG-TERM PLANNING

32) No in-depth long-term planning is carried out. For example, no in-depth market analysis, engineering analysis, or manufacturing spend. The strategic review for the parent company is primarily of a financial nature.

33) No structured design meetings involving engineering, sales, materials and production at the earliest stages of design process.

34) Poor co-ordination between sales and production in the creation of hew Master Production Schedule.

35) Sales do not have overall control over the Master Production Schedule, and thus, do not have the final say relative to the sequential running of orders.

CONFLICT MANAGEMENT

36) A high level of conflict would appear to exist within the company, but with a low level of conflict management.

PERFORMANCE MEASUREMENTS

37) No measurement of purchasing performance, obtained by the total number of orders received late or early divided by the total number of orders placed

38) No measurement of production performance, obtained by the orders completed beyond due date, divided by the total number of orders in the shop.

39) No measurement of supplier performance, obtained by the total number of orders received late divided by the number of orders placed with the supplier.

40) No performance measurement of forecast error, obtained by the estimated demand divided by the actual demand.

41) No performance measurement of orders past due, obtained by the current portion of items not completed on time divided by the number of items on the current schedule

42) No performance measurement of the average length of past due orders in days.

43) No performance measurement of the £ value of past due orders completed late in the month, divided by the monthly sales.

44) No performance measurement of the orders shipped complete (Including service and requirement parts), the goal being 100%.

45) No performance measurement of the orders shipped on time (including the above), the goal being 100%

46) No performance measurement of the £ value of late and/or incomplete orders versus the total monthly shipments, the goal being zero.

47) No performance measurement of the £ value of items on backorder versus the total monthly shipments.

48) No performance measurement of the % of monthly shipping schedule shipped each week, the goal being 25%

49) No performance measurement of how late are orders that are being shipped late.

50) No performance measurement of the % of orders being closed short (with respect to the number of shop orders flowing through the system of a given period).

These performance measurements should be made visible to all employees

Having organised the company for change, Education and Training programs were prepared for a number of weeks ahead to facilitate further discussion on the potential improvements available to the company. With this emphasis on education and training in phase two, the type of education program delivered by the author, in conjunction with the project team and other staff is highlighted in appendix 7. Indeed, the fifth session on problem solving was facilitated by using the ideas developed by Stewart [195] thus showing the link to the academic literature which helped build upon the content of the Current Reality Audit Document originally.

The second part of the Way Forward phase involves planning for change. At this point the Managing Director decided to go ahead with a software solution to the problem created by the existing computer system , hence the selection of the software system was to run in parallel with the existing actions selected for improvement from the above list. The project team, with the aid of the steering committee decided to undertake the following analysis:

* Report on B.O.M. accuracy
* Examination of performance measurements
* Feasibility of single stores location with limited access
* Reduction/elimination of quarantine area
* Robustness of all disciplines and procedures
* Education and training requirements

The Implementation Phase

This phase was dominated by the selection and implementation of the new production planning and control system, which was considerably draining on the human resources of the company in terms of the time taken up by such activities.

As the Framework Document highlights, the third phase should operate in 'and/or' mode, but unfortunately, the focus provided by the initial project teams and steering committees disappeared once the software consultants arrived, simply because the data requirements of such as system were very demanding.

However, the author was heavily involved in the selection and implementation of the computer system as well, and consequently, the framework document was shown to work well in conjunction with a software house. Namely, the hands on experience of the software trainers was complemented by the education aspects from the framework document developed by the author. Secondly, the framework document provides an independent view on the production planning and control area. Appendix 8 shows the selection and evaluation criteria developed to test potential vendors and their software.

Current Reality Phase

Phase four, involves revisiting the Current Reality Phase to feedback results from phase 3, and to focus on new improvements. With company A, the whole process flow from phase 1 to phase 3 took two and a half years. The company now have a very good computerised production planning and control system, which they are delighted with, so in that aspect, the implementation was a success. In particular, report generating is almost at 'best practice' level. However, although the software and indeed the system has developed, the software has actually outgrown the company, in that the company has suffered a downturn in business. In addition, the Group who own the company, and who allow it a fairly free rein, have bought another similar company to Company A, and are asking the management team at Company A to manage both companies.

Although the author is not so closely involved with the company now, it is hoped that they will move onto the feedback loop and tackle the supplier development issues, which they can now measure accurately, but still suffer poor performance. Hence the Supplier Relations Issues table of the framework would be of particular use to them.

6.2.2. Company B

Background

Company B are a subsidiary of an American owned conglomerate, assembling safety restraints, in particular, seat belts and buckles, air-bags and both mechanical and pyrotechnic retractors or buckle pretensioners. They are a first-tier supplier to most of automotive assemblers in Europe. Turnover equates to approximately 145,000 retractors per week and buckles per week or £7 million turnover for 1994. of which 70% is exported to the European market.

New business opportunities will equate to a further 40,000 retractors per week. The shopfloor is very labour intensive, with mass production in Business Units each servicing a particular customer. The Group Headquarters in the USA have a strong TQM culture which the corporation as a whole embraced in 1990.

Current Reality Phase

The Current Reality Audit Document for company B, is presented in appendix 9. A number of the main issues arising from this phase are now discussed.

Strategic Issues (Table 1)

Performance measurement within the business units was under investigation, with shopfloor personnel encouraged to collect their own statistics. The Business Units recognised the need to change and encouraged sub-measures which contributed to targets being set. Despite this, however, forecast accuracy and B.O.M. accuracy scored low in the audit document.

According to the Manufacturing Strategy subsystem, company B lack design capabilities, and compete in a fairly standard product environment. To counteract this, the company are trying to generate a number of core services including;

* Design rigourness
* Specialise in critical assembly.
* Increasing time spent on the most complex pieces of technology.
* Customer-focused. One planner/unit. Customer interface with spreadsheets.
* Product families.

Unlike company A, who had a large degree of autonomy from their parent, Company B receive their strategic plans and objectives from corporate headquarters in the United States. Current Reality in this company concerns the number of improvement programs imposed upon them from the States. In the last 3 years, the company has undertook lean manufacturing, Inventory control, cost reduction program, product data management program, Advanced Project Management, and Activity-Based Costing.

Product Issues (Table 2)

As can be seen from table 2, New Product Introduction is an area of concern for the company. Failure to obtain contracts for generic replacements with 2 major customers had resulted in an increase in marketing activity to gain market share. Winning new business had been hampered by the technological advancements made by the competition within the industry. At the time of the Current Reality Audit, the company did not have a core product portfolio with which to offer the customer base a competitive package at a competitive price.

The requirement to offer a complete in-car safety system is now prominent when responding to a customer request for quotation. A complete system includes safety restraints, airbags, and child seats. The company's main competitor had the advantage of being able to offer this full package at the right time and at a competitive price. Increasing the resources in research and development and into the design functions had enabled the company to slow down the decline in market share

Unfortunately, during this time, the company gained a reputation in the marketplace for not meeting target dates, thus subsequently, emphasis has been placed on adding value to its supply chain and improving internal processes and systems to redress the balance even further. Development cycles are being squashed, although the company face styling constraints and thickness-of-door constraints on designs. The lack of achievement in modular design is thus problem, although this factor does not score the lowest possible rating.

Further problems highlighted by the Current Reality document were that Product Life Cycles were difficult to predict in terms of tail-off's. Engineering changes were excessive, and B.O.M. accuracy was poor, but again these two factors did not score the lowest rating.

Inventory Issues (Table 5)

Work-in-Progress was difficult to measure, with no tools being available, and a 'Blackhole syndrome' existing. Therefore, the company don't really know their cycle times. The existing MRP system was being run in hybrid mode with cellular manufacturing at the business unit level. Problems were arising from the lack of timeliness of MRP data, with purchasing transactions requiring the input data to be first of all transcribed onto a form. Shopfloor Data Collection was a live project 3 years ago, but a delay in selection of the system led to a cooling off and no subsequent system was introduced.

Workforce Issues (Table 6)

The overriding concern for Company B was change management. A poor attitude existed in terms of 'if it can't happen overnight, then it won't happen at all'. However, there were large differences between different areas of the factory. Manufacturing and the shopfloor had an excellent attitude to change, but a poor attitude came from services, support functions and surprisingly, top management. A real problem was the lack of formal mechanism for managing change.

Supplier Relations (Table 8)

Despite operating in the most advanced Supply Chain industry, the company's relationships with their suppliers was poor. In particular, there was no passing on of ideas and improvement techniques. It was although thought in some quarters, that the purchasing section were protecting supplier.

Way Forward Phase

Fortunately, the author of this study was given the opportunity to advise Company B over a 2 year period. The Current Reality Audit Document certainly worked in this environment, as reports were put forward, based on the Audit document, to suggest improvements in relationships with suppliers, including sending Industrial Engineers from the company to visit key suppliers , particularly in less busy spells.

In addition, the use of parallel sourcing as advocated by Richardson [220] was suggested, and the work of Winters, Steeple and Sara [116] is thought to offer promise in introducing Activity-based Costing in to the company's supply chain, particularly with applications to their suppliers.

The recent move by the company towards ABC may also bring about an improvement in. the WIP measurement problem on the shopfloor. The work of Lee and Billington [100] could also contribute to the future development of this company's supply chain.

Implementation Phase

This work is on-going in an advisory basis, but a problem in this type of environment, is that to reach Phase 3, is the competition from all the other programs of improvement being introduced by the Group Headquarters.

The remaining 8 case studies are considered in less detail, and the Current Reality Audit Documents are mapped onto appendix 10.

6.2.3. Company C

Background

Company C design, manufacture and assemble waveguide lasers, in a combination of Make To Stock (MTS) and Make To Order (MTO), with lower level assemblies in stock. Products are grouped by families of common technology, with 4 main groups: lower power waveguide lasers, medium frequency lasers, middle range power lasers and, very high power lasers. The company operate in a very competitive business environment, especially in middle range lasers.

Current Reality Phase (Summary)

Strategic Issues (Table 1)

From appendix *, it can be seen that there are a number of concerns facing the company.

Benchmarking is not carried out in the company because of a lack of resources.

Product Issues (Table 2)

Although BOM accuracy was hard to define, it was thought that from feedback from the shopfloor, that the accuracy was acceptable. .

Process Issues (Table 3)

Lead times are a particular concern for the company, and in the past year, long lead time have led to customers waiting for products.

The company is undertaking work on the leadtime problem. The company have a routing system of works orders cards and planning books, but the maintenance of routing and planning is a high overhead on effort.

Inventory Issues (Table 5)

The company need stock accuracy, which is currently in the low 90%'s. They do have cycle counting, having devised their own stock checking, targeting random checks over a certain time period. Procedures and disciplines within the company are troublesome. Documented effort is also a high overhead within the company, and there are some inaccuracies. However, there is an evolution in responsibility within the overall operation of the business. The company were, until recently, qualified for the AQ1 quality standard, but this has now expired. The next objective was to go for BS5750, mainly for a marketing advantage.

Although the current mainframe system is capable of MRP, the company believe that they do not need MRP, as they know how many they can build in a given time period. The feeling exists within the company, that the current computer system is too sophisticated for the company.

Workforce Issues (Table 6)

The level of education and training within the company has been low over the last couple of years, with money being ploughed into new product lines, although some engineers have been put on project management courses.

Supplier Relations Issues (Table 8)

With regards to purchasing, some products have a very high material cost. Over 80% of the effort in the company is in delivering material flow to the shopfloor.

The company are trying to cultivate relationships with suppliers, especially on crucial technology aspects or where they can see the opportunity to develop certain business leverages. The company used to buy components from a multiplicity of machine shops, but now are concentrating on suppliers who can supply product packages. Overall, they are trying to control supplier proliferation, as the supplier base is quite large.

Way Forward Phase (Summary)

The main issues recommended for further action in this phase were:

1) The development of an in-house education and training programme, designed with the objective of increasing inventory accuracy within the company. It was recommended that such a program also cover the problem of inaccuracy in the current documented procedures within the company.

2) An investigation of the local supplier base, to lead to the development of local suppliers who will alleviate the problems the company faces in delivery of materials to the shopfloor on time.

Implementation Phase (Summary)

Attempts have been made at implementation of the above issues within company C. However, the lack of resources, and a concentration by management on the day-to-day running of the operation have resulted in both programs floundering, with the result that the framework was not applied to the fourth stage, the feedback to the Current Reality Phase. However, overall, the framework was successful in identifying the key issues and problems facing the company.

6.2.4 Company D

Background

Company D's business is the design and the manufacture of high technology products, with 4 major product ranges; power supplies, microwaves, contract business and connectors. The company occupy a fully equipped 120,000 sq.ft facility which houses all the corporate functions of marketing, finance, human resources, research, development and manufacturing. Approximately 60% of the team are involved with production. Over 20% are scientists and engineers who are graduates in many different disciplines. The remaining 20% are part of the administrative team.

The company's philosophy is to have all the elements of sound design and quality incorporated into every phase of the product's design and manufacturing cycle. The company is approved to supply under the following quality systems; BS5750 part 1, AQAP - 1, CAA, CECC and BS9000. It is the company's technology and its ability to make that technology commercially viable which is the real strength of Company D.

Current Reality Audit (Summary)

Product Issues (Table 2)

Engineering change is a problem on certain products, with B.O.M.'s being updated only from the engineering department. Typical B.O.M.'s have a very deep structure, of 12-25 levels. The number of component per product, typically, 2000, increases the complexity of the product..

Process Issues (Table 3)

Production lead times are not as the company would like, and work is being undertaken to record accurate information from the purchasing section.

Inventory Issues (Table 5)

Despite having a mainframe system, the company do not have the ability to carry out full material traceability. The manual system in operation at the moment is rather painstaking.

Workforce Issues (Table 6)

The attitudes to change within the company, is by the fear factor. That is, people are basically forced to follow changes, or leave the company.

Education and training is a problem area within the company. With regard to production planning and control education and training, the people who were supposed to carry out education and training have left the company.

Supplier Relations Issues (Table 8)

Materials are very specialised and expensive within the company, and work is being undertaken to identify new suppliers relatively close to the company. With 75% of materials purchased, and a small machine shop facility, the company are trying to reduce costs by persuading raw material suppliers, subcontractors and other suppliers to hold stock for them. Delivery problems exist with a large number of suppliers being located elsewhere in the U.K. A major problem, however, with local suppliers, is that a large electronics company have a big influence on the area, and tend to have a strong influence on company D's deliveries.

Way Forward Phase (Summary)

The main issues recommended for further action in this phase were:

1) The instigation of an education and training program to explore the workforce's understanding of production planning and control systems.

2) The allocation of resources to the problem of full material traceability.

Implementation Phase (Summary)

An education programme similar to that designed and operated for company A, strongly recommended. However, the lack of resources within the company forced the delay of this programme.

The company have made progress in the steps towards facilitating full material traceability via the existing computerised production planning and control system. The identification by the Current Reality Audit Document, of full material traceability being an area of concern for a large number of people, was enough to focus effort on this problem.

Again, as in company C, the feedback loop to the existing Current Reality Phase was not undertaken, because of a lack of time and resources.

6.2.5. Company E

Background

Company E is a small sub-contract precision machine shop, supplying as per customer requirements to high technology industries. The company is 11 years old.

Current Reality Phase (Summary)

Strategic Issues (Table 1)

The company have very little measures of performance in place, and consequently, score the lowest rating in the Measures of Performance subsystem.

With regards to Manufacturing Strategy, the company is also in the unenviable position of producing standard products, requiring little design expertise.

Capacity Issues (Table 4)

The company lack the capacity data necessary to plan and control shopfloor workloads and schedules. The lack of time standards and routing information leads to serious capacity problems.

Inventory Issues (Table 5)

There is a strong need for production control and capacity planning. Projects are being undertaken to install a CIM - DNC link. At present, the lack of MRP is of concern, especially taken with the current capacity problems. Of immediate concern, is the lack of Master Production Scheduling within the company. The use of such a system, with Rough Cut Capacity Planning would relieve capacity and production planning and control problems within the company.

Workforce Issues (Table 6)

The lack of formal systems within the company is of concern, as is the lack of resources which can be devoted to education and training within the company. This will be especially important in the future if any improvements in the existing production planning and control system are to be realised.

Way Forward Phase (Summary)

The main issues recommended for further action in this phase were:

1) The company examine the implementation of a Shopfloor Data Control system to alleviate the problems caused by up to date capacity information.

2) The company also examine the feasibility of introducing Master Production Scheduling and Rough Cut Capacity Planning.

Implementation Phase (Summary)

The company are undertaking a feasibility study of implementing the above systems. A major problem is likely to be the lack of resources to devote to education and training within the company. In company E, the lack of measures of performance was raised as a potential area to address. However, the management team decided that resources should be devoted to the planning and control of capacity. Due to a lack of resources, the company are still operating in the Way Forward Phase of the framework, and it is not known whether they shall move on to the feedback phase in due course, or stop at the end of the third phase.

6.2.6. Company F

Background

Company F, design, manufacture and assemble microwave products for military and commercial customers.

Current Reality Phase (Summary)

Capacity Issues (Table 4)

The company have a number of capacity restrictions in the business. A major bottleneck is in the testing area which is sophisticated, and limited, by the number of people who have the skills to operate the test equipment. In addition, the company often have to subcontract assembly work to local subcontractors.

Inventory Issues (Table 5)

Inventory obsolescence is a problem for the company at the moment. Inventory accuracy is also running at 65-70%. The company are currently in a mid-flight implementation of a new computerised production planning and control system. Problems are being experienced with the changeover, with two systems operating in tandem at the moment. The new computer system was selected by the American parent of company F. Indeed, the company feel as though they are the guinea pigs for the rest of the group. The existing computer system is very inflexible with regards to order placing and changing. With the new system, cycle counting will be properly set-up.

The need for MPS has become apparent within the company (This has also been indicated in the Master Production section table 2).

Workforce Issues (Table 6)

Education in production planning and control is becoming a problem within the company, especially the impact the new system will have on other people.

Supplier Relations Issues (Table 8)

The lack of supplier development is a major problem for the company. The American parent company have a large machine shop, and try to impose raw material and components on the company. Efforts are being made to move towards local suppliers. The company will be driving towards JIT delivery of supplies.

Customer Relations Issues (Table 9)

There is a need for the company to regain the confidence of its customers with regard to delivery performance. This is particularly true in the space products market.

Way Forward Phase (Summary)

The main issues recommended for further action in this phase were:

1) An education and training problem be undertaken to try and improve the level of inventory data integrity, and to help alleviate the stock obsolescence problem.

2) An examination of local suppliers, to identify a few key companies who may be willing to develop longer-term relationships with company F.

Implementation Phase (Summary)

As company F are in mid-flight implementation of a new computerised production planning and control system, and experiencing problems in changeover, the opportunities for developing the Way Forward Issues were predictably limited. However, the need for Master Production Scheduling, identified in the Current Reality Phase, should be facilitated by the new computer system. The benefit of the framework in this company, is again, the focus it provides to implementation efforts. The company were being forced to implement a new computer system selected by the American parent organisation. Therefore, the opportunity was lost to undertake education and training of issues such as inventory accuracy, as recommended by the Way Forward Phase. In addition, the company could also undertake the recommended supplier development program, but again, the devotion of resources to the current system implementation is likely to limit action on this issue in the immediate future. The development of suppliers could facilitate the improvement in capacity bottleneck problems and delivery performance to customers. It is unknown if company F will be proceeding to the feedback phase of the framework.

6.2.7. Company G

Background

Company G make to customer order, design, manufacture and assemble high technology products for the communications industry.

Current Reality Phase (Summary)

Company G are the only company to score consistently highly on the Current Reality Audit Document. However, a number of issues have been highlighted.

Capacity Issues (Table 4)

The company have had full MRP for 10 years, but do not have capacity planning. This lack of capacity planning is causing problems at present because the plant is working to almost full capacity levels.

Inventory Issues (Table 5)

The company are experiencing inventory accuracy difficulties, and do not have limited access to the stores.

Way Forward Phase (Summary)

Only two low score areas have been identified in company G. Therefore, the main issues raised were;

1) The investigation of the feasibility of introducing a capacity management system.

2) The undertaking of full education and training in the area of inventory data accuracy.

Implementation Phase (Summary)

An education and training program was designed by the author and the management team at company G, with the objective of reducing the inventory accuracy problems within the company. This program was very similar to that designed for company A, in that emphasis was placed on the potential behind the existing production planning and control system, if the company could correct the inventory integrity problems. Particular emphasis was placed on developing procedures and disciplines to limit access to the stockroom, an area identified in the Current Reality Phase as being a hindrance to accurate inventory data. A feasibility study of the company introducing a capacity planning and control system was also undertaken, especially the possibility of Rough Cut Capacity Planning which would allow simple capacity planning and control, and would not be so dependent on accurate data from the existing production planning and control system. Both of these activities are ongoing in company G, but it does seem likely that this company will move forward to the feedback phase in due course.

6.2.8. Company H

Background

Company H, design, manufacture, and assemble retail petroleum service products. At the time of the study, the company was moving into a new factory, as German production being transferred U.K. Two other European-based factories in France and Holland produce similar products. The company could produce and distribute to German customers faster than the existing German facility could, hence the moving of production to the study site. The company undertake volume production in cells by types of products, for example, sizes. Eighty nine percent of products are produced for the European market.

Current Reality Phase (Summary)

Workforce Issues (Table 6)

Persistent conflict exists between sales and manufacturing. The pressures on manufacturing from sales are also not helped by BOM's not being structured and engineered properly (a table 2 issue).

Supplier Relations Issues (Table 8)

The company is trying to place forecasting risk with suppliers. The supplier base of 150-175 is being actively reduced, especially important given the very high purchasing, and very little in-house manufacturing capability of the company.

Customer Relations Issues (Table 9)

Demand from customers is difficult to gauge, with each individual oil company and garage distributor producing different demand patterns (also highlighted in the Manufacturing Strategy subsection of table 1).

Way Forward Phase (Summary)

The main issues recommended for further action in this phase were:

1) An education and training program designed to facilitate a reduction in conflict between departments, with particular focus on manufacturing/sales relationships.

2) An investigation into the feasibility of improving forecasting of customer demand.

Implementation Phase (Summary)

Both of the recommendations have been put on hold because of the additional pressures of having to cope with increased production from the transfer of the German facility to the U.K. Again, it is unlikely that company H will proceed to the feedback phase.

6.2.9. Company I

Background

Company I, make-to-order and assemble microwave cable. Cable is purchased from the parent company in the U.S. The company produce a range of hundreds of different cable.

Current Reality Phase (Summary)

Process Issues (Table 3)

The existing computerised production planning and control system has a capacity planning facility, but the company don't use it. Instead, they rely heavily on safety stocks, based historically on usage over the last year. Two months stock are held for key components. The cable purchased from the U.S. parent company has a purchasing lead time of 4 weeks. Indeed, the lead times entered on the system for purchased parts do not really mean anything to the production planners.

Supplier Relations Issues (Table 8)

The company is working on a supplier development program to encourage good local performance from suppliers, with the overall aim to have the supplier turnkey the operation.

Customer Relations Issues (Table 9)

Demand fluctuates, with a mid-summer dip, but overall, demand is not easily defined.

Way Forward Phase (Summary)

The main issues recommended for further action in this phase were:

1) An investigation of the purchasing strategy within the company.

2) An examination of the inventory control policies and procedures within the company.

Implementation Phase (Summary)

The above conclusions from the Way Forward Phase indicated that strategic decisions had to be made regarding the purchase of cable within the company. Indeed, the above recommendations were not undertaken because of the political ramifications if the decision was made to purchase cable from a source other than the American parent. Therefore, this company is unlikely to proceed to the feedback phase of the framework. A supplier development program could be introduced to attempt to reduce the reliance on safety stocks within the company, but again, with a lack of top management commitment, this is unlikely to be successful.

6.2.10 Company J

Background

Company J, manufacture capillary and compression fittings for the plumbing and heating industry, with close and established links with customers and trade links. The company offers 3 product ranges; integral lead free solder ring fittings, compression fittings, and end feed fittings.

All 3 ranges are produced in the UK at companies on 2 manufacturing sites. A total of 1500 different products are manufactured. Both sites have been approved to BS5750 part 2 and ISO 9002 and are licensed under the Kitemark Scheme for approved patterns. Products are distributed via a network of 4 sales offices and depots in throughout the UK. The highly automated site in this study, manufacture 12-13 million component fittings per year, in a cellular production system based on size, for example, 15mm, 22-28, and small fittings.

Current Reality Phase (Summary)

Process Issues (Table 3)

Bottlenecks exist within the plant, in nut production, assembly, and the annealing plant (which was previously subcontracted).

The company is currently introducing a new 16 port, machine monitoring Shopfloor Data Collection System, as a team leaders tool. A pilot implementation is being undertaken, with 6 machines linked up, and 3 others to be linked up in the immediate future. Whereas most systems run by standard values, this system will tell actual cycle time on the shopfloor and then recalculate the planned time.

Inventory Issues (Table 5)

The company is also moving towards MRPII in the next 9 months. The new system was selected by Head Office. Part numbers often cause trouble for the system with problems with different metals, but tooling does remain the same. Stock control is complex with 8 different pieces, with 10,000 bodies and 10.000 spindles etc.

The company is looking at JIT/kanban, with consultants in the company at the moment, undertaking a feasibility study.

Workforce Issues (Table 6)

The company is based in an area of strong trade unions. However, the relationship between management and the workforce is mellowing.

Customer Relations Issues (Table 9)

The seasonal demand pattern, with winter production rising to cope with pipes freezing up, is to a certain degree passed onto suppliers, who are asked to hold stock for the company.

Way Forward Phase (Summary)

This stage was rather pre-emptied by the existence of a large number of projects already underway within the company. The implementation of a new MRP system, the pilot implementation of a Shopfloor Data Control System, and a feasibility of JIT and kanban, meant that the company was not interested in moving forward to the implementation phase of the framework.

The results of these case studies are considered in detail in chapter 7.

Chapter 7

Discussion of Results

This study has identified both from case studies and from the existing literature, that a significant number of characteristics influence the selection, improvement and implementation of production planning and control systems. A consolidated framework has been developed and tested in ten small manufacturing companies in the U.K.

This chapter will provide a discussion of the results obtained in the ten case study companies. In particular, attention will be paid to how the framework has helped the ten companies develop their production planning and control systems.

The framework aided the selection and implementation of a new computerised production planning and control system in company A. The Current Reality Audit analysis within the company pinpointed a number of significant characteristics impinging upon the performance of the current production planning and control system. The negotiated characteristics to move into the Way Forward Phase included disciplines and procedures, inventory accuracy, supplier performance, education and training, communications, long-term planning, conflict management and performance measurements. Problem-solving in these areas was proposed and undertaken. This type of problem-solving proved to be crucial, and allowed the company to move forward into the implementation phase.

The undertaking of such a project was draining on the human resources within the company. It was found in particular that the volume of data to be collected was overwhelming, but a successful implementation a new computer system can take place in a small manufacturing company.

In particular, the lack of human resources reduced the number of improvements that could be undertaken. For example, one of the major problems facing the company was supplier relations, and these were ignored to a certain degree. Despite the company now having state of the art computer system and report generation capabilities, existing problems still exist with supplier relations. Revisiting the Current Reality Audit stage would help identify current problems.

Company B allowed the study of a first-tier supplier in the automotive industry. This company was failing to gain new business because of a number of problems identified by the framework. In this longitudinal analysis, company B were advised to improve relations with their suppliers, and a number of suggestions were made. The use of Industrial Engineers in suppliers' plants was advocated, and plans to introduce a parallel sourcing program were presented, through the use of activity-based costing. The use of Supply Chain Modelling was also suggested in this environment, especially given the problems with a lack of timeliness with the existing MRP system.

A number of common problems can be identified from the case studies. For example, supplier relations problems were also highlighted in five of the other eight companies, with companies C, F, H and I all being advised to improve these relations via the Way Forward Phase. Overall, seven of the ten case study companies were recommended to improve supplier relations, thus advocating the use of the Supply Chain Management approach to the selection, improvement and implementation of production planning and control systems.

Eight of the ten case study companies were operating MRP/MRP II systems, but with limited success. Data collection and integrity was a limiting factor for the success of these systems, with companies C, E, F, G, and H, all experiencing such problems. These problems could be attributed to a combination of, inventory accuracy, B.O.M. complexity and accuracy, and lead time accuracy.

Of the other two companies not operating MRP II, company E identified the need for such a production planning and control system, and company J were going to implement MRP II within nine months of the case visits. Thus, despite its data complexity, MRP is still the preferred system for production planning and control.

Of the ten cases, companies A, C, D and F, all experienced education and training problems, which would seem to indicate a common problem with small companies. This was usually attributed to a lack of financial resources within the company.

Another common problem facing the small companies was the lack of formal systems and procedures being in place. Companies A, C, D and E all suffered from a lack of formal systems.

There is a distinct lack of capacity planning in operation within all 10 companies. Eight of the companies scored the lowest possible rating with regard to the use of Capacity Requirements Planning (CRP), with the other two companies scoring the second lowest score with regard to that characteristic. Companies E, G, I and J all indicated the need for simple capacity planning such as Rough Cut Capacity Planning (RCCP) in conjunction with Master Production Scheduling. Again, this lack of capacity planning can be linked to the lack of real time data, especially from shopfloor control and feedback systems.

The improvements available from the framework can be achieved with little or no financial investment, although it is acknowledged that human resources are likely to be scarce. As mentioned previously, education and training does suffer when financial resources are scarce within the company. The lack of human resources was the most common reason put forward for the companies not proceeding to the feedback phase of the framework.

The danger for small companies is that too much time is spent collecting data for improvements, and too much time is spent measuring performance.

Interdepartmental coordination is still poor in small companies, and there is an important part for human factors to play in the selection and implementation phases. Many of the improvements to be made are in the general management area, for example, organizational integration techniques. Interdepartmental conflict was a major problem in companies, A and H. The lack of good change management can also be attributed to small company management.

Hybrids are the way forward, as local business units gain in prominence. Three of the companies studied had such units in place. This allowed the framework to be used a number of times in these companies, facilitating a triangulation process of validation to take place within each company.

Re-implementations are important, given the number of companies who are implementing a new production planning and control system after previous, and more likely than not, arduous implementations in the past.

However, a number of advantages were obtained with small companies. Top management commitment was easier to obtain, with management being more closely involved in the day to day running of the company.

More specific conclusions will now be discussed in chapter 8 with regards to the design and operation of the framework.

Chapter 8

Conclusions

The objective of this chapter is to arrive at some conclusions regarding the empirical work undertaken in this study.

A number of questions were posed in chapter one, under the objectives of the study. A framework has been developed which satisfies these objectives.

The first question posed, was whether or not a framework can be provided to aid small manufacturing companies in successfully implementing production planning and control systems. This has been achieved, as can be seen by referring to the results achieved in chapter 6, and summarised in chapter 7.

Education and Training plays an integral part in the operation of the framework. Whereas software house provide the training on a detailed level on the actual use of the computer system, the Way Forward Phase of the framework encourages users to design their own education program. Many of the main subjects in such a program involve subjects such as problem-solving. This was a major problem in the implementation in company A, as any problems arrived on the doorstep of engineering. Off-the-shelf education programs are totally inadequate for use, unless extensively adapted to the company's environment, both internal and external.

Software still has a role to play in the framework. The framework developed gives you an implementation choice of either a new computerised solution or to focus on a number of small incremental improvements. If a software solution is recommended, then the framework can be used in conjunction with the software company.

The software company provide detailed hands-on training in the workings of the software solution, whereas the framework allows education at management level regarding the impact that the change will have on the supply chain. However, a danger during implementation is that too much power is given to the computer support staff such as IT. The implementation in company A was Engineering led, with the help of the author and a good implementation organization.

A normal implementation plan lacks the focus that such a framework can provide. The existing literature does not provide comprehensive enough conceptual frameworks and models for the selection and implementation of production planning and control systems.

The second question posed in the study objectives, was if lessons can be learned from both suppliers and customers when selecting and implementing new production planning and control systems.

The idea of the framework is to put the company in both the suppliers shoes and the customers shoes. There is need for the company to fill in both customer and supplier sections, and then compare the answers from the suppliers and customers themselves. Obviously time wise, only the main customers and suppliers can be studied in this way, or with customers and suppliers they hope to do business with. However, the discussion of the results in chapter 7 proves that certainly supplier relations are crucial to the selection, improvement and implementation of production planning and control systems.

The third question posed in chapter one, was, if there are major differences between small and large companies when it comes to implementing production planning and control systems.

Large companies either tend to have their own consultant division, or employ the large consulting firms hence such a framework as the one developed in this study have a role to play when the company is toward the lower end of the SME with regard to number of employees.

A key factor in the successful implementation of production planning and control systems in small companies is the introduction of a user-led approach. The Current Reality and Way Forward sections of the framework allow the users of the system/improvements to create a customer-focused set of improvement techniques in a simplistic format.

Top management still play a very important part, especially in providing that initial drive and desire to improve their operations.

The fourth question posed, revolves around whether action research can allow the framework to be developed. The author was fortunate to be involved in an action research study of the selection and implementation process in company A. It was found that the framework was ideally suited to the action research methodology, in that the volume of information to be collected throughout the four stages requires an in-depth understanding of the company under study.

The action research methodology also facilitates the application of a number of phases to a particular problem, such as presented in the framework. Thus, action research allows a longitudinal interpretation of a company situation, and limits the possibility of misinterpretation of results. However, the role of a consultant has to be examined carefully in relation to action research. In particular, a definition of responsibilities has to outlined between the roles of researcher and consultant.

It was also found that the large number of background questions allowed a very comprehensive understanding of the inner workings of the company. Therefore, although many of the questions posed in the Current Reality Audit Document are not directly mentioned in the literature search, they have contributed to the success of the operation of the framework.

The final question posed, was whether or not incremental improvements lead to a satisfying outcome for smaller manufacturing companies. Only one of the ten case studies resulted in a new computerised production planning and control system. The remaining nine small companies were given recommendations to undertake projects for small incremental improvements in performance of their manufacturing systems. The value of the framework therefore lies in allowing the company under study to focus their efforts in a relatively small number of areas. Therefore, it is an excellent tool for problem identification and solving in small manufacturing companies. This is particularly important given the lack of financial and, in particular, human resources in small companies.

Recommendations for further research and application of the framework are presented in chapter 9.

Chapter 9

Recommendations for Further Work

It is the objective of this chapter to discuss a number of recommendations for future work of the framework developed in this study. The framework has a number of implications for managers in small manufacturing concerns, consultants to small companies, and researchers of small business production planning and control. Each of these will be discussed in turn, and a discussion of the limitations of the study will be undertaken.

The framework developed in this study can be used by managers in small manufacturing companies to either select, implement or improve their existing production planning and control systems. To date, the author has undertaken the research in the companies and applied the framework. However, it is intended that the users themselves apply the framework by means of the Rationale For Inclusion of each characteristic. Thus, future work will involve taking the existing rationale for inclusion details and producing this in a book or workbook format, giving guidelines at each phase of the framework, and providing the rational behind each of the questions posed in the framework. The framework can then be used as a self-audit tool and managers could use it to examine some underlying assumptions within their company. The framework will also increase the awareness within the company of a certain technique.

The framework can also be used for education and training purposes within companies, although this could be especially difficult given the propensity for small businesses to cut down on such expenditure when faced with a recession or a downturn in business.

The framework can also be used as a consultancy tool. It should be recognised that standard answers will not help small companies with production planning and control problems, and large consultancy firms have a tendency to sell solutions to fit the company. This framework fits the company situation. There is a particular emphasis in this framework on the human factors involved in the operation of a production planning and control system.

Future work can also be done by researchers in the field of production planning and control. The framework fills a gap in the literature by allowing small companies to select and implement new systems from a Supply Chain Management perspective.

The framework could be applied to particular industrial sectors, and could thus facilitate the comprehensive analysis of a particular Supply Chain. This may be limited to the companies willing to participate, and could cause a confidentiality and trust problem. There is also the possibility of undertaking a comparative analysis of the characteristics affecting the selection, implementation and improvement of production planning and control systems in a manufacturing environment, with those prevalent in a service operations environment.

The framework can also be used in the future in a modular fashion, and quantitative measures could also be designed for use with the framework. Thus, for example, a company may wish to analyse their supplier relations on a stand-alone basis, although the danger here, is that the holistic picture is lost. The use of quantitative measures would also allow companies to benchmark against each other. The Likert Scale as a measure is adequate in the present mode of use of the framework, and it is acknowledged that it is very difficult to measure characteristics such as flexibility.

The limitations of this study can also be overcome in the future. The characteristics within the framework tend to be piecemeal, and no attempt has been made to interlink various characteristics, thus it could be argued that results are limited to cautious generalizations.

In addition, the framework will require continuous updating to take into account new developments in the field of production planning and control, both from the literature, and from practice found in industry.

The framework can be used within larger companies which are made up of smaller groups. A number of the companies studied were part of a larger group, and the parental control can limit the validity of the exercise.

More best practice case studies could be built up by studying a number of Japanese transplants. Of the companies examined, only one (company B) supplied the Japanese. Thus, the framework could be applied in a number of countries, allowing comparisons between countries.

There are a number of practical limitations to the use of longitudinal and action research type methodologies. Company A took 2.5.- 3 years to implement a new computerised solution with the help of the framework. To get the necessary depth of understanding of the selection and implementation process, it is necessary to spend a great deal of time within the company. This does limit the number of sites that can be visited in the future.

The future use of surveys would produce a snapshot of a company at any given time, therefore future use of the framework has to be by case study research, preferably with action research methodologies. A combination of action research and self-analysis by managers could be deigned as a methodology.

Case selection in this study was primarily through the ease of access. The use of the framework by a researcher requires good contacts at a high level within the company, and the building of trusting relationships.

Future uses of such a framework are likely to increase given the ever increasing trend toward the purchasing of parts and the subcontracting of sub-systems.

Small companies in particular must look at the threats and opportunities presented within their supply chains and identify gaps where an improvement in their production planning and control system will lead to increased business by, for example, shortening lead times, and/or reducing costs. Such a company must examine the underlying assumptions in their relations with both customer and suppliers. Too many such companies immediately quote the lack of bargaining and purchasing power as being a deterrent to supplier relations. Therefore, this framework will be a powerful tool for small manufacturing companies in the future.

References

[1] Ptak. C.A. (1991), 'MRP, MRP II, OPT, JIT, AND CIM - Succession, Evolution, or Necessary Combination' Production and Inventory Management Journal, 32 (2), pp7-11.

[2] Gilbert, J.P., and Schonberger R.J. (1983) ,'Inventory-Based Production Control Systems: A Historical Analysis', 24 (2), pp1-15.

[3] Lee, C.Y., (1992), 'A Recent Development of the Integrated Manufacturing System: A Hybrid of MRP and JIT', Integrated Manufacturing Systems, 3 (2), pp20-23.

[4] Millard, R.I. (1985), 'MRP is None of the Above', Production and Inventory Management, 26 (1), pp22-30.

[5] Hannah, K.H., (1987), 'Just-in-Time: Meeting the Competitive Challenge', Production and Inventory Management Journal, 28 (3), pp 1-3.

[6] Sewell, G., (1990), 'Management Information Systems for JIT Production', Omega, International Journal of Management Science, 18 (5), pp491-503.

[7] Kochhar, A., and McGarrie, B, (1992), 'Identification of the Requirements of Manufacturing Control Systems: A Key Characteristics Approach' Integrated Manufacturing Systems, 3 (4), pp4-15.

[8] Newman, W.R., and Sridharan, V., (1992), 'Manufacturing Planning and Control: Is There One Definitive Answer' Production and Inventory Management Journal , 33 (1), pp50-54.

[9] Berry, W.T., and Hill, T. (1992) 'Linking Systems to Strategy' International Journal of Operations and Production Management, 12 (10), pp. 3 - 15

[10] Krupp J.A.G., (1984) 'Why MRP Systems Fail: Traps to Avoid', Production and Inventory Management, 25 (3), pp207-212

[11] Blackstone, J.H., and Cox, J.F. (1985) 'MRP Design and Implementation Issues for Small Manufacturers' Production and Inventory Management Journal, 26 (4), pp 65-76.

[12] Torkzadeh, G., and Sharma, N., (1991), 'MRP Application in a Small Manufacturing Company', Industrial Engineering, 23 (6), pp43-46.

[13] Brown K.L., and Inman R.A., (1993), 'Small Business and JIT: A Managerial Overview', International Journal of Operations and Production Management, 13 (3), pp57-66.

[14] St. John, C.H., and Heriot, K.C., (1993), 'Small Suppliers and JIT Purchasing', International Journal of Purchasing and Materials Management, 29 (1), pp11-16.

[15] Herroelen, W.S., Lambrecht, M.R., (1989), 'Manufacturing in a Post-Industrial Society', European Management Journal, 7 (2), pp182-188

[16] Gardner, J.A., (1992), Common Sense Manufacturing, Richard D. Irwin, Inc., Homewood, Illinois.

[17] Krupp, J.A.G., (1986), 'MRP Re-Implementation', Production and Inventory Management, 27 (4), pp73-81.

[18] Saunders, M., (1994), Strategic Purchasing and Supply Chain Management, Pitman Publishing, London.

[19] Willis, T.H. and Huston C.R.,(1990) 'Vendor Requirements and Evaluation in a Just-In-Time Environment', International Journal of Operations and Production Management, 10 (4), pp41-50.

[20] Richman, E., and Zachary, W.B., (1994), Industrial Management, 36 (2), pp24-27.

[21] Brenizer, N.W., (1987) , 'The Bottom Line Begins at the Top---Revisited', Production and Inventory Management Journal, 28 (4). pp28-31.

[22] Orlicky J.A., Plossl G.W., and Wight O.W., (1972), 'Structuring the Bill of Material for MRP', Production and Inventory Management, 13 (4), pp 19-42.

[23] Wallace T.F., and Dougherty J.R., eds., (1987), APICS Dictionary, sixth edition, APICS, Falls Church, VA.

[24] Ware N., and Fogarty D.W., (1990), 'Master Schedule/Master Production Schedule: The Same or Different?', Production and Inventory Management, 31 (1), pp34-38.

[25] Ling R.C. and Sari F.J., (1986), Master Production Schedule, chapter 13, APICS Handbook, pp13.3 -13.50

[26] Maes, J., and Van Wassenhove, L.N., (1991), 'Functionalities of production-inventory control systems' Production Planning and Control, 2 (3), pp 219-227.

[27] Gardiner, S.C., Blackstone, J.H., and Gardiner, L.R., (1993), 'Drum-Buffer-Rope and Buffer Management: Impact on Production Management Study and Practices', International Journal of Operations and Production Management, 13 (6), pp68-78.

[28] Fawcett, S.E., and Pearson, J.N., (1991), 'Understanding and Applying Constraint Management in Today's Manufacturing Environments' Production and Inventory Management, 32 (3), pp46-55.

[29] Goyal, S.K., and Deshmukh, S.G., (1992) 'A Critique of the Literature on Just-in-Time Manufacturing', International Journal Of Operations & Production Management, 12 (1), pp 18-28.

[30] Bartezzaghi, E. and Turco, F., (1989) 'The Impact of Just-in-Time on Production System Performance: An Analytical Framework', International Journal of Operations and Production Management, 9 (8), pp40-62.

[31] Zipkin, P.H., (1991), 'Does Manufacturing Need a JIT Revolution?', Harvard Business Review, 69 (1), pp40-46.

[32] Cheng, T.C..E., (1991), 'Some thoughts on the Practice of just-in-time', Production Planning and Control, 2 (2), 167-178.

[33] Pegler, H.C., and Kochhar, A.K., (1990) ,'Rule-based approach to just-in-time manufacturing' Computer-Integrated Manufacturing Systems, 3 (1), pp11-18.

[34] Voss, C.A., and Robinson, S.J., (1987) 'Application of Just-in-Time Manufacturing Techniques in the United Kingdom', International Journal of Operations and Production Management, 7 (4), pp46-52.

[35] Heiko, L., (1989), 'A Simple Framework for Understanding JIT', Production and Inventory Management, 30 (4), pp 61-63.

[36] Oliver N., (1990), 'The Dynamics of just-in-time', New Technology, Work and Employment, pp 19-27.

[37] Singh, N., and Brar, J.K., (1992), 'Modelling and Analysis of Just-in-Time Manufacturing Systems: A Review' International Journal of Operations and Production Management, 12 (2), pp3-14.

[38] Wemmerlov, U., and Hyer, N., (1987), 'Research Issues in Cellular Manufacturing', International Journal of Production Research, 25 (3) pp413-31.

[39] Kamenetzky, R.D., (1985), 'Successful MRPII Implementation Can be Complemented by Smart Scheduling, Sequencing Systems', Industrial Engineering, 17 (10), pp44-52.

[40] Marucheck, A.S., and Peterson, D.K., (1988) 'Microcomputer Planning and Control for the Small Manufacturer: Part 1: MRP and Planning', Production and Inventory Management, 29 (1), pp34-37.

[41] Cooke, C., (1989) 'A Stock Improvement Methodology for the Small Manufacturing Company' BPICS Control, 15 (5), pp33-37.

[42] Hendry, C., Arthur, M.B., and Jones A.M., (1995), Strategy Through People: Adaptation and Learning in the Small-Medium Enterprise, Routledge, London.

[43] Cambridge Small Business Research Centre (SBRC), (1992), 'The State of British Enterprise', University of Cambridge.

[44] Waterlow J.G., and Monniot, J., (1986), 'The State of the Art in CAPM in the UK', International Journal of Operations and Production Management, vol.7. no.1.

[45] Maull, R.S., and Childe, S.J., (1993), 'A step-by-step guide to the identification of an appropriate computer-aided production management system', Production Planning and Control, 4 (1), pp69-76.

[46] Bessant J. and Buckingham J., (1993), 'Innovation and Organizational Learning: the Case of Computer-Aided Production Management', British Journal of Management, 4 , pp 219-234.

[47] Little, D., (1990), 'Survey of UK Manufacturing Control Practice', BPICS Control 16 (3), pp31-32.

[48] Barber, K.D. and Hollier, R.H.,(1978), ' The Use of Numerical Analysis to Classify Companies According to Production Control Complexity' International Journal of Production Research, 24 (1), pp203-222.

[49] Grunwald, H., Striekwold, P.E.T., and Weeda, P.J., (1989) 'A Framework for Quantitative Comparison of Production Control Concepts', International Journal of Production Research, 27 (2), pp 281-292.

[50] The Institution of Production Engineers, An Executive Guide to Manufacturing Control Systems Selection, Compiled by members of the Manufacturing Information Systems Working Party (date unknown).

[51] Luscombe, M., (1991), 'Design and Implementation of Integrated Production Control Systems', Integrated Manufacturing Systems, 2 (4), p 4 - 8

[52] Larsen, N.E., and Alting L, (1993), 'Criteria for selecting a production control philosophy', Production Planning and Control, 4 (1), pp54-68.

[53] Plenert, G., (1992), 'Manufacturing management - a world model?', Production Planning and Control, 3 (1), 93-98.

[54] Burcher P. (1992) 'Master Production Scheduling and Capacity Planning: The Link?' Integrated Manufacturing Systems, 13 (4), pp16-22.

[55] Tobias, A.M., (1991), 'Managing the redesign of manufacturing systems', International Journal of Technology Management, Special Issue on Manufacturing Strategy, 6 (3/4), pp375-384,

[56] Slack, N. and Correa, H., (1992), 'The Flexibilities of Push and Pull', International Journal of Operations and Production Management, 12 (4), pp 82-92

[57] Kim, G.C., and Schniederjans, M.C., (1990), 'An Evaluation of Computer-Integrated Just-In-Time Production Systems' Production and Inventory Management Journal, 31 (1), pp4-7.

[58] Cooper R.B., and Zmud R.W., (1989), 'Material Requirements Planning System Infusion', OMEGA, International Journal of Management Science, 17 (5), pp471-481.

[59] Yoo, S., (1989), 'An Information System for Just-In-Time', Long Range Planning, 22 (6), pp117-126.

[60] Fiedler K., Gallently, J.E., and Bicheno, J. (1993) 'Expert Advice for JIT Implementation', International Journal of Operations and Production Management, 13 (6), pp23-30.

[61] Karlsson C. and Norr C., (1994), 'Total Effectiveness in a Just-in-Time System', International Journal of Operations and Production Management, 14 (3), pp44-65.

[62] Millar, I., (1990) 'Total Just in Time', Industrial Management and Data Systems, 90 (2), pp3-10.

[63] Oliver, N., (1990) 'Human Factors in the Implementation of Just-In-Time Production', International Journal of Operations and Production Management, 10 (4), pp32-40.

[64] Rainnie, Al., (1991), 'Just-In-Time Subcontracting and the Small Firm', Work, Employment and Society, 5 (3), pp. 353-375.

[65] Vora, J.A., Saraph, J.V., and Petersen, D.L., (1990), 'JIT Implementation Practices', Production and Inventory Management, 31 (3), pp57-59.

[66] Zantinga, J.T., (1993), 'Improvements in Spanish Factories: Towards a JIT Philosophy?', International Journal of Operations and Production Management, 13 (4), 40-49.

[67] Giunipero, L.C., and O'Neal, C., (1988), 'Obstacles to JIT Procurement' Industrial Marketing Management, 17 (1), 35-41.

[68] Gupta, Y.P., (1989), 'A Feasibility Study of JIT Purchasing Implementation in a Manufacturing Facility', International Journal of Operations and Production Management, 10 (1), pp31-41.

[69] Hassard, J.S., and Proctor, S.J., (1991), 'Manufacturing Change: Introducing Cellular Production in Two British Factories', Personnel Review, vol.20, no.4., pp15-24.

[70] Afzulpurkar, S., Huq, F., and Kurpad, M., (1993) 'An Alternative Framework for the Design and Implementation of Cellular Manufacturing', International Journal of Operations and Production Management, 13 (9), pp4-17.

[71] Blackstone, J.H., and Cox, J.F. (1985) 'Selecting MRP Software For Small Businesses' Production and Inventory Management Journal, Fourth Quarter, pp 42-50.

[72] McManus, J.P., (1989), 'Developing a Detailed MRP-II Implementation Plan' Production and Inventory Management Journal, 30 (2), pp 75-79.

[73] Vargas, G.A., and Dear, R.G., (1991), 'Managing Uncertainty in Multilevel Manufacturing Systems', Integrated Manufacturing Systems, 2 (4), pp14-26.

[74] Kinnie, N.J., Staughton, R.V.W., and Davies, E.H., (1992), 'Changing Manufacturing Strategy: Some Approaches and Experiences' International Journal of Operations and Production Management, 12 (7/8), pp92-102.

[75] Smith, S., and Tranfield, D., (1989), 'A Catalytic implementation methodology for CIM', International Journal of Computer Integrated Manufacturing, 2 (3), pp140-147.

[76] Duchessi, P., Schaninger, C.M., and Hobbs, D.R., (1989) 'Implementing a Manufacturing Planning and Control Information System' California Management Review, 31 (3), pp75-90.

[77] Cerveny R.P. and Scott L.W. (1989), 'A survey of MRP Implementation', Production and Inventory Management, 30 (3), pp31-34.

[78] Burns, O.M., Turnipseed, D. and Riggs, W.E., (1991) 'Critical Success Factors in Manufacturing Resource Planning Implementation', International Journal of Operations and Production Management, 11 (4), pp. 5 - 19

[79] Banerjee, S. and Golhar, D.Y. (1993), 'EDI Implementation: A Comparative Study of JIT and Non JIT Manufacturing Firms', International Journal of Physical Distribution and Logistics management, 23 (7), pp. 22-31.

[80] Daniel, S.J. and Reitsperger, W.D., (1991) 'Management Control Systems for JIT: An Empirical Comparison of Japan and the U.S.' Journal of International Business Studies, 22 (4), pp603-617.

[81] Dion, P.A., Banting, P.M., Picard, S., and Blenkhorn, D.L. (1992), 'JIT Implementation: A Growth Opportunity for Purchasing', International Journal of Purchasing and Materials Management, 28 (4), pp 32-38.

[82] Freeland, J.R., (1991), 'A Survey of Just-In-Time Purchasing Practices in the United States', Production and Inventory Management Journal , 32 (2), pp43-51.

[83] Giunipero, L.C., (1990), 'Motivating and Monitoring JIT Supplier Performance', Journal of Purchasing and Materials Management, 26 (3), pp19-24

[84] Ingersoll Engineers, The Quiet Revolution Continues, A survey of Implementation and Performance of Cell Manufacture Across British Engineering Companies, 1993, Rugby, Warwickshire.

[85] Inman, R.A., and Mehra, S., (1993), 'Financial Justification of JIT Implementation', International Journal of Operations and Production Management, 13 (4) pp 32-39.

[86] Keller A.Z., Kazazi A., and Carruthers A., (1992), 'Impact of Implementing "Just-in-Time" in a European Manufacturing Environment', International Journal of Quality and Reliability Management, 9 (7), pp54-63.

[87] Vonderembe, M., Tracey, M., Tan, C.L., Bardi, E.J., (1995), 'Current purchasing practices and JIT: some of the effects on inbound logistics', International Journal of Physical Distribution and Logistics Management, vol.25, no.3, pp33-48.

[88] Kochar, A. and Suri, A., (1992) 'Gap Analysis Approach to the Effective Implementation of Master Production Scheduling Systems', Integrated Manufacturing Systems, 3 (2), pp20-23.

[89] Lin N.P., Krajewski, L, Leong G.K., Benton, W.C., (1994), 'The effects of environmental factors on the design of master production scheduling systems', Journal of Operations Management, vol.11, pp 367-384.

[90] Murthy, D.N.P., and Ma, L., (1991), 'MRP with uncertainty: a review and some extensions' International Journal of Production Economics, 25, 51-64.

[91] Schlussel, B.M., (1990), 'Twelve Reasons MRP II Can Fail In Your Company and What You Can Do About It', APICS Conference Proceedings, pp 436-438.

[92] Chan, J.S., Samson, D.A., and Sohal A.S., (1990) 'An Integrative Model of Japanese Manufacturing Techniques', International Journal of Operations and Production Management, 10 (9).

[93] Harber, D., Samson, D.A, Sohal, A.S., and Wirth, A., (1990) 'Just-in-Time: The Issue of Implementation, International Journal of Operations and Production Management, 10 (1), pp21-30.

[94] Lummus, R.R., and Duclos-Wilson, L., (1992), 'When JIT is not JIT', Production and Inventory Management Journal, 33 (2), pp61-65.

[95] MacBeth, D.K., (1987) 'Supplier Management in Support of JIT Activity: A Research Agenda', International Journal of Operations and Production Management, 7 (4), pp53-63.

[96] Safayeni, F., Purdy, L., van Engelen, R., Pal, S., (1991) 'Difficulties of Just-in-Time Implementation: A Classification Scheme' International Journal of Operations and Production Management, 11 (7), pp27-36.

[97] Stamm, C.L., and Golhar, D.Y., (1993) 'JIT purchasing: attribute classification and literature review' Production Planning and Control, 4 (3), 273-282.

[98] Willis, T.H., and Suter, W.C., (1989), 'The Five M'S of Manufacturing: A JIT Conversion Life Cycle' Production and Inventory Management, 30 (1), pp53-57.

[99] Kaplan, R.S., and Norton, D.P., (1992) 'The Balanced Scorecard - Measures that Drive Performance', Harvard Business Review, 70 (1), pp 71-79.

[100] Lee, H.L, and Billington, C., (1992) 'Managing Supply Chain Inventory: Pitfalls and Opportunities' Sloan Management Review, 33 (3), pp 65-73.

[101] Kivijarvi, H. and Tuominen, M., (1991), 'Logistics Management: a method for evaluation of production-distribution investments' International Journal of Production Economics, 24, pp115-128.

[102] Hendricks, J.A., (1994) 'Performance Measures for a JIT Manufacturer: The Role of the IE' Industrial Engineering, 26 (1), pp26-29.

[103] Sweeney, M.T., (1994), ' A Methodology for the Strategic Management of International Manufacturing and Sourcing' , The International Journal of Logistics Management, 5 (1), pp55-65

[104] Partovi, F.Y., (1994) 'Determining What to Benchmark: An Analytic Hierarchy Process Approach', International Journal of Operations and Production Management, 14 (6), pp25-39.

[105] Daugherty, P.J., Droge, C., and Germain, R.,(1994) 'Benchmarking Logistics in Manufacturing Firms' The International Journal of Logistics Management, 5 (1), pp9-18.

[106] Ohinata, Y., (1994), 'Benchmarking: The Japanese Experience' Long Range Planning, 27 (4), pp48-53.

[107] Sweeney, M.T., (1994), 'Benchmarking for Strategic Manufacturing Management', International Journal of Operations and Production Management, 14 (9), pp4-15.

[108] Mosquera, J., and Lange, T., (1993) 'Looking Inward First', Manufacturing Breakthrough, 2 (2), pp17-20.

[109] Daley, L., Jiambalvo, J., Sundem, G.L., Kondo, Y., (1985), 'Attitudes Towards Financial Control Systems in the United States and Japan' Journal of International Business Studies, 16 (3), pp91-110.

[110] Kaplan, R.S., (1984) , 'Yesterday's accounting undermines production' Harvard Business Review, 62 (4), pp95-101

[111] Hiromoto, T., (1988), 'Another hidden edge - Japanese management accounting', Harvard Business Review, 66 (4), pp22-26.

[112] Green, F.B. and Amenkhienan, F.E, (1992) 'Accounting Innovations: A Cross-Sectional Survey of Manufacturing Firms', Journal of Cost Management, 6 (1), pp58-64.

[113] Harmon R.L., (1992), 'Reinventing the Factory II', Free Press, New York, p267.

[114] Primrose, P.L., (1990) 'Selecting and Evaluating Cost-effective MRP and MRPII', International Journal of Operations and Production Management, 10 (1), pp51-66.

[115] Greenwood, T.G., and Reeve, J.M., (1992), 'Activity-Based Cost Management for Continous Improvement: A Process Design Framework', Journal of Cost Management, 5 (4), pp22-40.

[116] Winters, C, Steeple, D.,and Sara, G, (1994) 'Supplier Selection and Development through Activity Based Cost Management, First International Conference of European Operations Management Association, Cambridge University Press, pp343-347.

[117] Tatikonda, M.V., (1988), 'Just-in-Time and Modern Manufacturing Environments: Implications for Cost Accounting', Production and Inventory Management, 29 (1), pp 1-5.

[118] Hayes, R.H., and Clark, K.B., (1988), Dynamic manufacturing: Creating the learning organization, New York: The Free Press.

[119] Anderson J.C., Schroeder R..G, and Cleveland G., (1991), 'The Process of Manufactuirng Strategy: Some Empirical Observations and Conclusions', International Journal of Operations and Production Management, 11 (3), pp86-110.

[120] Watts, C.A., Kim, K.Y., Hahn, C.K., (1992), 'Linking Purchasing to Corporate Competitive Strategy', International Journal of Purchasing and Materials Management, 28 (4), pp2-8.

[121] Garvin, D.A., (1993), 'Manufacturing Strategic Planning', California Management Review, 35 (4), pp 85-106.

[122] Monczka, R.M., and Trent, R.J., (1992) 'Worldwide Sourcing: Assessment and Execution', International Journal of Purchasing and Materials Management, 28 (4), pp9-19.

[123] Bozarth C.C., (1993), 'A Conceptual Model of Manufacturing Focus', International Journal of Operations and Production Management, 13 (1), pp 81-92.

[124] Taylor, S.G. (1987) ,'Focused Production Systems', Production and Inventory Management, 28 (1) ,pp 28-37.

[125] Baker, R. (1993) ,'Value-adding Performance Measurement: A Time-based approach', International Journal of Operations and Production Management',13 (5), pp

[126] Blackburn, J.D. (1992) 'Time-Based Competition; White-Collar Activities' Business Horizons, 35 (4), pp 96-101..

[127] Dilton-Hill, K.G., and Glad, E, (1994), 'Managing Capacity', Journal of Cost Management, 8 (1), pp32-39.

[128] Handfield, R.B., (1994) 'US Global Sourcing: Patterns of Development' International Journal of Operations and Production Management, 14 (6) , pp40-51

[129] Fildes, R. (1992) ' Improving Sales Forecasting for Production and Inventory Control' BPICS Control, 18 (2), pp 27-30.

[130] Flynn, B.B., (1994), 'The Relationship between Quality Management Practices, Infrastructure and Fast Product Innovation', Benchmarking for Quality Management and Technology, 1 (1) , pp 48-61.

[131] Bohse, M.E. and Harhalakis G., (1987) ' Integrating CAD and MRP II Systems', CIM Review, Summer , pp 7-14.

[132] Bennett, D. and Forrester, P. (1994) 'Product Variety and Just-in-Time: Conflict and Challenge' The International Journal of Logistics Management, 5 (1), pp73-80.

[133] Cooper R. G. and Kleinschmidt E. J. , (1993),'Uncovering the Keys to New Product Success', Engineering Management Review, 21 (4), pp5-18.

[134] Cusumano, M.A., (1994) 'The Limits of "Lean"' Sloan Management Review, 30 (3), pp27-32.

[135] Benton and Srivastava, (1985) 'Product Structure Complexity and Multilevel Lot Sizing Using Alternative Costing Policies' Decision Sciences, 16, pp357-369.

[136] Lambrecht, M.R., and Van den Wijngaert, F., (1985), 'A Microcomputer System of MRP and Scheduling in Essochem' , Production and Inventory Management, 26 (4), pp59-69.

[137] De Toni, A., Filippini, R., Forza, C. (1992), 'Manufacturing Strategy in Global Markets: An Operations Management Model', International Journal of Operations and Production Management, 12 (4), pp7 - 18.

[138] Heard E.L., (1986), 'A JIT Implementation Plan and a Platform for Selling it to Top Management, APICS Conference, Toronto, APICS, Falls Church, VA., PP1-9.

[139] Kanet, J.J., (1986) 'Inventory Planning at Black and Decker' Production and Inventory Management, 25 (3), pp115-123.

[140] Harhalakis, G., (1986), 'Engineering Changes for Made-to-Order Products' , Engineering Management International, 4, pp 19-36.

[141] Handfield, R.B., and Pannesi, R.T., (1992) , 'An Empirical Study of Delivery Speed and Reliability' International Journal of Operations and Production Management, 12 (2), pp58-72.

[142] Vastag, G. and Whybark, D.C., (1993),'Global relations between inventory, manufacturing lead time and delivery date promises', International Journal of Production Economics, 30-31, pp563-569.

[143] Christopher, M., and Braithwaite, A., (1989), 'Managing Strategic Lead Times', Logistics Information Management, 2 (4), pp192-197.

[144] Sugden P., (1985) 'The Way Towards JIT Manufacturing', Production Engineer, June, pp22-23..

[145] Prickett, P., (1994) 'Cell-based Manufacturing Systems: Design and Implementation', International Journal of Operations and Production Management, 14 (2), pp4-27.

[146] Rao, A. and Scheraga, D.I., (1987), 'Systems for Supporting the MRP II/JIT Environment', CIM Review, Summer, pp15-23.

[147] Schonberger, R., (1986), World Class Manufacturing , The Lessons of Simplicity Applied, The Free Press, New York.

[148] Burgoine, J. (1988) 'Beyond MRP II' Production Engineer, January, pp 31-33.

[149] Donovan, M., (1990), 'Enhancing the Schedule Execution Capability of MRP Systems', APICS Conference Proceedings, 33rd International Conference October 8-12, New Orleans, APICS, Falls Church, Virginia, pp193-195.

[150] Hall, R.W., (1986) 'The Care and Feeding of Top Management', APICS MRP Reprints, Falls Church, Virginia, pp 131-136.

[151] Gelders, L., and van Wassenhove, L., (1985), 'Capacity Planning in MRP, JIT and OPT: A critique' Engineering Costs and Production Economics, 9 (3), pp201-209.

[152] Minifie, JR. and Davis, R.A., (1986) 'Survey of MRP Nervousness Issues' Production and Inventory Management, pp111-120.

[153] Gerwin, D., (1986) 'An Agenda For Research on the Flexibility of Manufacturing Processes', International Journal of Production Management, 7 (1), 38-44.

[154] Gallimore, K.F., and Penlesky, R.J. (1988) ' A Framework for Developing Maintenance Strategies', Production and Inventory Management, 29 (1), pp16-21

[155] Maggard, B.N., and Rhyne, D.M., (1992), 'Total Productive Maintenance: A Timely Integration of Production and Maintenance', Production and Inventory Management, 33 (4), pp6-10.

[156] Towill, D.R., Naim, M.M., and Wikner, J., (1992) 'Industrial Dynamics Simulation Models in the Design of Supply Chains' , International Journal of Physical Distribution and Logistics Management, 22 (5), pp3-13.

[157] Florida, R., and Kenney, M. 'Organisation vs. culture: Japanese automotive transplants in the US', Industrial Relations Journal, pp 181-196

[158] McNair, C.J., (1994), 'The Hidden Cost of Capacity', Journal of Cost Management, 8 (1), pp12-24.

[159] Proud, J.F., (1986) 'Using the MRP Output', APICS MRP Reprints, pp 39-48.

[160] Pacos R.G. and Sinn J.W., (1989), 'An Evaluation of the Finished Goods Inventory System at Westinghouse Electrical Systems Division', Production and Inventory Management, 30 (4), pp45-48.

[161] Kim, T., (1985), 'Just-in-Time Manufacturing System: A Periodic Pull System', International Journal of Production Research, 23 (3), pp 553-62.

[162] Neeley, P.S., (1987), 'Simple Mathematics Applied to Inventory Accuracy', Production and Inventory Management Journal, 28 (3). pp64-68.

[163] Reichart, D., (1976) 'MRP Can Be Better the Second Time Around, But.......', APICS Conference Proceedings ,pp 447-466.

[164] Graff, R.T., (1987) 'The Limitations of Cycle Counting', Production and Inventory Mnagement Journal, 28 (4), pp 39-43.

[165] Martin, J.W, and Goodrich, P.S., (1987) 'Minimizing Sample Size for Given Accuracy in Cycle-Counting', Production and Inventory Management Journal, 28 (4) pp24-27.

[166] Elliot, P.M. (1985), 'Nonsignificant Part Numbering: The Better Choice for MRP', Production and Inventory Mnagement, 26 (4), pp 102-108.

[167] South, J.B., and Hansen, L., (1991), 'Large Inventories as a Competitive Strategy', Production and Inventory Management, 32 (2), pp51-54.

[168] Dillon R.E., (1990), 'Some Simple Steps to Inventory Reduction', Production and Inventory Management, 31 (1), pp62-65.

[169] Lockyer, K.G., and Wynne, R.M., (1989) 'The Life Profile of Stock as a Control Measure', International Journal of Operations and Production Management, 9 (1), pp57-66.

[170] Toelle, R.A., and Tersine, R.J. (1989), 'Excess Inventory: Financial Asset or Operational Liability?', Production and Inventory Management', 30 (4), pp32-35.

[171] Natarajan, R., (1991), 'Inventory Management - The Big Picture' Production and Inventory Management, 32 (4), pp29-31.

[172] Benton, W.C., (1986) , 'Purchase Lot Sizing Research for MRP Systems, International Journal of Operations and Production Management, 6,(1), pp5-14.

[173] Jones, D.J. (1991), 'JIT and the EOQ Model', Management Accounting, 72 (8), pp54-57.

[174] Haddock J., Hubicki D.E.(1989), 'Which Lot-Sizing Techniques are used in Material Requiremnts Planning', Production and Inventory Management', 30 (3), pp53- 56.

[175] Saunders, G., (1987) 'How to use a Microcomputer Simulation to determine order quantity', Production and Inventory Management Journal, 28 (4), pp 20-23.

[176] Waples, E., and Norris, D.M., (1989), ' Just-In-Time Production and the Financial Audit', Production and Inventory Management Journal, 30 (4), pp 25-27.

[177] Karmarkar, U., (1989), 'Getting Control of Just-in-Time' Harvard Business Review, 67 (5), pp122-131.

[178] White R.W., (1986), 'Is it Time for a Physical Exam of your Material Requirements Planning System?', Production and Inventory Management, 27 (3), pp24-29.

[179] Malko, R.W., (1976) 'Master Scheduling: A Key to Results', APICS Conference Proceedings, pp181-191.

[180] Conti, R.F. and Warner, M., (1993) 'Taylorism, new technology and just-in time systems in Japanese manufacturing', New Technology, Work and Employment, 8 (1), 31-42.

[181] Sayer, A., (1986), 'New developments in manufacturing: the JITsystem', Capital and Class, 30, 43-72.

[182] Dawson, P., and Webb, J., (1989) 'New Production Arrangements: The Totally Flexible Cage?' Work, Employment and Society, 3 (2), June pp221-238

[183] Bratton, J., (1991) 'Japanisation at work: the case of engineering plants in Leeds',Work, employment & society, 5 (3), pp. 377-395

[184] Woodcock, D., and Weaver, R., (1993) , ' The Worker Competences Needed to Support World Class Manufacturing', Integrated Manufacturing Systems, 4 (1), pp30-36.

[185] Mueller, F., 'Flexible working practices in engine plants: evidence from the European automobile industry', Industrial Relations Journal, pp191-204.

[186] Parthasarthy, R., and Sethi, S.P. (1992), 'The Impact of Flexible Automation on Business Strategy and Organizational Structure', Academy of Management Review, 17 (1), 86 - 111

[187] Inman, R.A., and Boothe, R.S., (1993), 'The Impact of Quality Circles on JIT Implementation' International Journal of Quality and Reliability Management, 10 (7), pp7-15.

[188] Hiltrop, J.M., (1992), 'Just-in-Time Manufacturing: Implications for the Management of Human Resources' European Management Journal, 10 (1), pp 49-55.

[189] Hinterhuber, H., and Popp, W., (1991), 'Strategic Leadership Competence', chpt.8, International Review of Strategic Management, Ed. by Hussey D.E., John Wiley, London.

[190] Brown, A.D., (1993), 'Leading Technological Change', Leadership & Organization Development Journal, 14 (4), pp. 21-26

[191] White, E.M., and Flores, B., (1987) 'Goal Setting in the Management of Operations', International Journal of Operations and Production Management, 7 (6), pp 5-16.

[192] Galvin, P.C., (1986) , 'Vision and Realities: MRP as "System', Production and Inventory Management, 27 (3), pp91-95.

[193] Hartley, K., (1983) 'How to Plan and Organise an MRP Project', Production and Inventory Management, 24 (1), pp 53-65.

[194] Helms, M.M., Thibadoux, G.M., Haynes, P.J. and Pauley, P., (1990) 'Meeting the Human Resource Challenges of JIT through Management Development, JMD, 9 (3), pp28-34.

[195] Stewart, J., (1991), 'Managing Change Through Training and Development', Kogan Page, London.

[196] Newman, A., and Kirk, S., 'MRP II - Implementation On a Microcomputer: Case Studies', American Production and Inventory Control Society, Microprocessor Seminar Proceedings, pp 29-34.

[197] Millard, R.I., (1989), 'Is MRP Training Aimed in the Right Direction?', Production and Inventory Management Journal, 30 (2), pp 22-26.

[198] Crittenden V.L., (1992) 'Close the Marketing/Manufacturing Gap', Sloan Management Review, Spring, pp41-52.

[199] Powers T.L., Sterling J.U. and Wolter J.F., (1988), 'Marketing and Manufacturing Conflict: Sources and Resolution', Production and Inventory Management Journal, pp 56-60, 1st Quarter, 1988.

[200] Dale B.G. and Shaw P., and Owen M., (1990) 'SPC in the motor industry: an examination of implementation and use', International Journal of Vehicle Design, 11 (2), pp115-131

[201] Schniederjans, M.J., (1993), 'Topics in Just-In-Time Management', Allyn and Bacon, Needham Heights, Massachusetts.

[202] Ajala, C. (1992) 'Wasteful Practices: Handicaps to the JIT Process', Industrial Engineering, 24 (1), pp55-57.

[203] Turnbull, P., Delbridge, R., Oliver, N., and Wilkinson, B., (1993), 'Winners and Losers - The 'Tiering' of Component Suppliers in the UK Automotive Industry', Journal of General Management, 19 (1), pp48-63.

[204] Romero, B.P., (1991), 'The Other Side of JIT in Supply Management', Production and Inventory Management, 32 (4), pp1-3.

[205] Parnaby, J., (1991) 'Designing effective organizations', International Journal of Technology Management, 6 (1/2), pp 15-32.

[206] Jackson, S. and Browne, J., (1992), 'AI-based decision support tool for strategic decision making in the factory of the future', Computer-Integrated Manufacturing Systems, 5 (2), pp83-90.

[207] Ettkin, L.P., (1987) 'Thats a Good Idea, but---', Production and Inventory Management Journal, 28 (3), pp48-49.

[208] Miller, D.C., (1983), Handbook of Research Design and Social Measurement, 4th Ed., New York, Longman.

[209] Likert, R., (1967) 'The Human Organization', New York. McGraw-Hill

[210] Miles, M.B., and Huberman, A.M., (1994), Qualitative Data Analysis, Sage Publications, London.

[211] Taylor, S., and Bogdan, R, (1984), Introduction to Qualitative Research Methods, John Wiley, New York.

[212] Yin, R., (1989), Case Study Research Design and Methods, Revised Edition, Sage Publications, London.

[213] Bryman, A. (1989), Research Methods and Organisation Studies, Unwin Hyman, London.

[214] Marshall, C. and Rossman, G.B.(1989), Designing Qualitative Research, Newbury Park, California: Sage Publications.

[215] Silverman, D., (1993), Methods for Analysing Talk, Text and Interaction, Sage Publications, London.

[216] Burgess, R.G., (1984), In the Field: an Introduction to Field Research, George Allen and Unwin, London.

[217] Jorgensen, D.L.,(1989), Participant Observation: a Methodology for Human Studies, Sage, Newbury Park, California.

[218] Lincoln, Y.S., and Guba, E.G.,(1985), Naturalistic inquiry, Sage, Beverley Hills, California.

[219] Moser, C.A., and Kalton, G., (1983), Survey Methods in Social Investigation, second edition, Gower, Hants.

[220] Richardson, J., (1993), 'Parallel Sourcing and Supplier Performance in the Japanese Automobile Industry', Strategic Management Journal, vol.14, pp339-350.

APPENDIX 1

TABLE 2.1. LITERATURE REVIEW SUMMARY

Table 2.1. Literature Review Summary

Author (s)	Year	Type of PPC considered	Output	Environment Considered	Method of Validation
Afzulpurkar, Huq, Kurpad	1993	Cellular Manufacturing	CSF for cell implementation	(U.S.) Single site, energy service	Case study
Banerjee and Golhar	1993	Comparison JIT and Non-JIT	EDI impact on performance	(U.S.), Wide range	Survey, 25 JIT, 25 Non-JIT
Barber and Hollier	1986	Production Control	Classification according to production control complexity, and 6 basic company classifications	Engineering batch manufacturing	Survey, 88, cluster analysis
Bartezzaghi and Turco	1989	JIT	Analytical framework, JIT applicability	Small and medium sized in Italy	Future validation in small and medium Italian sites
Berry and Hill	1992	MPC's	Framework linking market needs with manufacturing strategy	Furniture manufacturer (U.S.), telecomms. (Europe), agricultural mach. (U.K.), aerospace, (U.K)	4 case studies
Bessant and Buckingham	1993	CAPM	CAPM Implementation analysis, success and failure factors	Electronics (U.S.) 200 employ., Electronic systems for aerospace 400 employ., Electronic instrumentation 240 employ.	3 Case Studies
Blackstone and Cox	1985	MRP	Design and Implementation	(U.S..) Small manufacturers	Unspecified number of case studies
Brown and Inman	1993	JIT	Literature review on JIT and small businesses	Small manufacturers	None
Burcher	1992	MPS, Capacity, MRP/MRP II	Implementation Factors and Guidelines	50-10,000, Range in complexity	8 case studies, and survey 272
Burns, Turnipseed and Riggs	1991	MRP II	CSF in implementation	(U.S.), electric, electronic, fabricated metals, transportation, mean 400 employees	Survey, 238
Cerveny and Scott	1989	MRP	Implementation factors	U.S manufacturers	Survey, 433
Chan, Samson, Sohal	1990	Japanese Manufacturing Techniques	Contextual Model	None	None
Cooper and Zmud	1989	MRP and Reorder Point Control	Factors facilitating and inhibiting MRP Implementation	U.S., large range of industry types	Survey, 250.
Daniel and Reitsperger	1991	JIT	Comparison of management control systems in Japan and U.S.	Large U.S. and Japanese electronics manufacturers	Survey, 679 in Japan, 789 in U.S. Factory visits?
Dion, Banting, Picard, Blenkhorn	1992	JIT	Summary of findings resulting from JIT implementation, on purchasing opportunities	New England, NAPM members, wide range	40 purchasing managers interviewed by phone, 20 interviewed face to face
Duchessi, Schaninger, Hobbs	1989	MRP/MRP II	Factors for successful MRP/MRP II Implementation	Large range of industries (U.S.)	Survey, 272

Fiedler, Galletly, Bicheno	1993	JIT	Expert-system for JIT implementation	U.K. batch manufacturer	One company validation. Further validation intended
Freeland	1991	JIT	Characteristics of JIT purchasing practices	U.S., wide range	survey, 60
Giunipero	1990	JIT	Factors for analyzing JIT supplier performance	U.S., 12 major SIC codes	Survey, 100
Giunipero and O'Neal	1988	JIT	Key barriers to JIT purchasing implementation	U.S., Fortune 500, major business areas; communications systems, automotive electronics, advanced electronic components	One case study
Goyal and Deshmukh	1992	JIT	Literature classification and critique, future research directions	None	None
Grunwald, Striekwold, Weeda	1989	Production Control	Framework to compare concepts in production control	None	Future simulation experiments
Gupta	1989	JIT	Feasibility study of JIT purchasing	North American manufacturer, multinational	One case study
Harber, Samson, Sohal, Wirth	1990	JIT	Primary factors for JIT implementation	None	Actual JIT implementations being studied in Australia
Hassard and Procter	1991	Cellular Manufacturing	Change process in moving to cellular manufacturing	U.K., multinational engineering group	2 cases within the same group
Heiko	1989	JIT	Simplified conceptual model for JIT	None	None
Ingersoll Engineers	1993	Cell Manufacture	Implementation and performance factors	British engineering companies, selection across SIC codes (SIC3000-3999), minimum size 10 million pounds turnover	Survey, 51 companies
Inman and Mehra	1993	JIT	Factors linking JIT benefits to financial success	U.S., wide range of types of industry and size of company	Survey, 114
Institution of Production Engineers	None	Manufacturing Control Systems	Executive guide to selection	None	None
Karlsson and Norr	1994	JIT	Implementation effects suppliers/manufacturers	Automotive companies in Sweden, suppliers	2 case studies, one manufacturer, one supplier
Keller, Kazazi, Carruthers	1992	JIT	Factors when implementing JIT	European manufacturers, wide range of types.	Survey, 66
Kim and Schniederjans	1990	Computer Integrated Just-In-Time (CIJIT)	Implementation problems	U.S., machinery, electrical, computer and transportation	Survey, 122
Kinnie, Staughton, Davies	1992	Manufacturing Strategy	Factors when implementing changes in manufacturing strategy	U.K., batch manufacturing, 2 small, 5 large	7 case studies
Kochhar and McGarrie	1992	Manufacturing Control Systems	Characteristics affecting selection and implementation	U.K., batch manufacturing	7 case studies

Kochhar and Suri	1992	MPS	Gap analysis approach for implementation	None	None
Larsen and Alting	1993	Production Control	Criteria and characteristics for analysing production control philosophies	None	None
Lee	1992	MRP/JIT	Factors for implementation of MRP/JIT hybrid	None	None
Lin, Krajewski, Leong, Benton	1994	MPS	Effects of environmental factors on design of MPS systems	Single item, made to stock, in an uncertain environment	Analytical cost model
Little	1990	Manufacturing Control	Profile of current manufacturing control practice	U.K., wide range, 95% more than 50 employees	Survey, 311
Lummus and Duclos-Wilson	1992	JIT	Factors for identification of JIT	None	None
Luscombe	1991	Integrated Production Control Systems	Model of Integrated Production Control, based on 5 principles	None	None
MacBeth	1987	JIT	Research model for JIT, need for research	None	None
Maes and Van Wassenhove	1991	Production and Inventory control	Framework for hybrid system, MRP, JIT, OPT	None	None
Marucheck and Peterson	1988	Microcomputer Planning and Control	Match between microcomputer planning and control and small manufacturers	U.S., small	None
Maull and Childe	1993	CAPM	Selection of CAPM, step-by-step guide	U.K., electronics sector, large	Unspecified number of case studies
McManus	1989	MRP II	Detailed implementation plan	U.S., Polymer Corporation	One case study
Millar	1990	JIT	Strategic Framework for implementation of JIT	Cummins Engine plant	One case study
Murthy and Ma	1991	MRP	Literature review on uncertainty	None	Future modeling
Newman and Sridharan	1992	Manufacturing Planning and Control	MPC and their best environment, performances relative	U.S., wide range, Ohio	Survey, 185
Oliver	1990	JIT	Human factors in the implementation of JIT	U.K., disguised	2 case studies
Pegler and Kochhar	1990	JIT	Rule based approach	None	None
Plenert	1992	Manufacturing Management	Model for manufacturing information flow	None	None
Ptak	1991	Combinations, MRP, MRP II, OPT, JIT, CIM	Factors for combining	None	None
Rainnie	1991	JIT	Buyer-supplier relations under JIT	Hertfordshire, high technology industries	6 large, and 13 small units
Safayeni, Purdy, van Engelen, Pal	1991	JIT	Classification of JIT implementation difficulties	Unspecified	Unspecified site visits
Schlussel	1990	MRP II	Reasons for implementation failure	None	None

Sewell	1990	JIT, and then compared with MRP	Conceptual comparison of MRP and JIT for management information systems	None	None
Slack and Correa	1992	MPC systems	Comparisons and measurement of flexibility under JIT and MRP	U.K..	2 case studies
Smith and Tranfield	1989	CIM	Implementation methodology	U.K.,	9 case studies
St. John and Heriot	1993	JIT	Model for describing environment of JIT manufacturers and threats, opportunities created for small suppliers	None	None
Staam and Golhar	1993	JIT	Literature review, JIT purchasing, attribute classification	None	None
Tobias	1991	Redesign of manufacturing systems, kanban and MRP	Task force approach	Lucas Industries	Unspecified number of case studies
Torkzadeh and Sharma	1991	MRP	Critical issues in implementation	U.S., small company. 60 workers on 2 sites. sensors	One case study
Vargas and Dear	1991	MRP	Identification of sources of uncertainty in MRP, and appropriate buffering strategies	Multi-level, multi-product manufacturing	Computer simulation of one company
Vonderembse, Tracey, Tan, Bardi	1995	JIT	JIT purchasing concepts	Mid-west, wide range	Survey, 268
Vora, Saraph and Petersen	1990	JIT	Implementation factors	U.S., electronics plants, SIC3560 Minnesota, with more than 100 employees	14 case studies
Waterlow and Monniot	1986	CAPM	State of the art in CAPM	U.K., SIC32 mechanical engineering, SIC34 electrical and electronic engineering	33 case studies
Willis and Suter	1989	JIT	Implementation guide	None	None
Yoo	1989	JIT	Identification of information requirements, comparison with MRP, integrated management information system	None	None
Zantinga	1993	JIT	Factory evaluation scheme for JIT improvements	Spanish factories, compared with improvements in Japan and Japanese transplants in Spain, automotive, electrical, electronics, medical and furniture	10 case studies, 2 of which were Japanese transplants

APPENDIX 2

LITERATURE CATEGORISATION SUMMARY

Strategic Issues (Table 1)

Characteristic Identified	Author (s)	Contribution to literature/Criticisms
Performance Measurements		
Use of performance measurements	Kaplan and Norton (1992)	Traditional measures are out of date.
	Lee and Billington (1992)	Common pitfall in supply chain management is the lack of supply metrics.
	Kivijarvi and Tuominen (1991)	Building performance measures for supply chains.
	Bartezzaghi and Turco (1989)	Issues in performance measurement.
Use of performance trends rather than absolute levels	Hendricks (1994)	Links critical success factors to measures of performance.
Selection of measures to use	Sweeney (1994)	Has an impact on organisational behaviour. Instruments designed to trigger the management of change.
Question the appropriateness of current measures of performance	Sweeney (1994)	Some measures can become permanent fixtures.
Benchmarking		
Use of benchmarking	Partovi (1994)	Which function to benchmark is crucial stage. Ways of identifying partners.
	Sweeney (1994)	For benchmarking, need an understanding of both the current and prospective role of the company in the supply chain.
	Daugherty, Droge, Germain (1994)	Test hypotheses regarding application of benchmarking.
	Ohinata (1994)	Limitations of benchmarking. Key success factors.
	Mosquera and Lange (1993)	Resource problem. Application of benchmarking to small companies.
Cost Control		
Budgetary control focus	Daniel and Reitsperger (1991)	Focus on short-term targets may be counterproductive to strategic focus.
	Daley, Jiambalvo, Sundem and Kondo (1985)	Attitudinal differences between line managers in U.S. and Japan, in regard to budgeting and control systems.
	Kaplan (1984)	Traditional US management accounting practices unsuitable to meet the needs of modern innovative manufacturing.
	Hiromoto (1988)	Japanese management control systems modified to reflect and promote strategic objectives.
	Green and Amenkhienan (1992)	"Productivity paradox" between accounting and manufacturing.
	Harmon (1992)	Japanese are gravitating towards the elimination of standard cost at the end product level.
	Primrose (1990)	Tangible and intangible costs associated with MRP implementation.
Activity-based costing	Greenwood and Reeve (1992)	Motivation for. and current limitations of.
	Winters, Steeple, Sara (1994)	Application of Activity-based costing in supplier development.
Process costing	Tatikonda (1988)	Pull control requires process costing systems.

	Lummus and Duclos-Wilson (1992)	JIT is not being applied if a company continues to use traditional methods of measuring efficiency and productivity.
Manufacturing Strategy		
Clear manufacturing/operations strategy	Hayes and Pisano (1994)	Key role for strategy is to guide selection of improvement programs.
	Anderson, Schroeder and Cleveland (1991)	Difference between manufacturing strategy process and content.
	Sweeney (1994)	Inconsistency between marketing and manufacturing management's visions of how corporate objectives of business could be accomplished
	Watts, Kim and Kahn (1992)	Purchasing and manufacturing strategies must be consistent.
	Garvin (1993)	Strategic manufacturing initiatives.
	Hayes and Clark (1988), Daniel and Reitsperger (1991)	The motivational value of manufacturing strategic controls triggers continuous improvement and learning.
	Oliver (1990)	Manufacturing system-market interactions are poorly understood.
	Berry and Hill (1992)	Framework for the linking of manufacturing strategy to the design of manufacturing control systems.
Stability of Industry	Monczka and Trent (1992)	Framework for identifying which category of stability applies to the company.
	Harber, Samson, Sohal, Wirth (1990)	Requirement for a suitable industrial infrastructure to implement full-scale JIT approach.
Competing in non-standard environment	St. John and Heriot (1993)	Potential supplier can standout; quality exceeding all industry standards; unique products; extraordinary design capability.
Competing in standard product environments	St. John and Heriot (1993)	Implications for suppliers in this environment.
Focused factory concept	Bozarth (1993)	Links consistency factors with performance.
	Taylor (1987)	Plan for developing focused systems.
Value-adding capability	Baker (1993)	Need restructuring of plants.
	Blackburn (1992)	White collar non-value adding.
	Dilton-Hill and Glad (1994)	Splits value chain between primary processes and secondary processes.

Product Issues (Table 2)

Characteristic Identified	Author (s)	Contribution to literature/Criticisms
Demand data		
Sales forecast accuracy	Handfield and Pannesi (1992)	Critical component of demand management, which provides the link between the planning and control system and market demand.
	Fildes (1992)	Limits to forecast accuracy. Techniques for improvement.
Coping with revisions of customer demand	Kochhar and McGarrie (1992)	High rate of revision of customer demand highlights the need for effective logistics and responsive control systems. If a company has the internal logistics in place to respond in a timely fashion to the external market demand, then all control functions benefit.
Design		
Design with Supply Chain Management in mind	Lee and Billington (1992)	Opportunities outlined. May be more expensive but give greater flexibility for meeting demand.
Concurrent (simultaneous) engineering	Flynn (1994)	Goal, reduced development time.
Design for Manufacture (DFM) and Design For Assembly (DFA)	Kochhar and McGarrie (1992)	Essential for the formulation of cells, and for the use of pull control. It also helps with the implementation and operation of all types of control systems.
	Maes and Van Wassenhove (1991)	One of key ideas on JIT improvement path.
	Flynn (1994)	Goal - Reduced time to ramp-up to full production.
Computer Aided Design (CAD)	Herroelon and Lambrecht (1989)	Significantly adds to product flexibility.
	Bohse and Harhalakis (1987)	Lack of integration CAD and MRP II. Reasons.
Modularised product designs	Herroelon and Lambrecht (1989)	Use of standardisation outlined.
	Bennett and Forrester (1994)	High variety/low volume production, benefits of modularised product designs can be greatly enhanced bv modularising production process.
Introduce New Products on schedule	Cusamano (1994)	Principles of lean management - Product Development. Honda Model outlined.
	Cooper and Kleinschmidt (1993)	Critical success factors for introduction of new products.
Ease of introducing new products	Kochhar and McGarrie (1992)	Product introduction rate affects the choice and suitability of capacity planning and scheduling, and of pull control. Low rate, pull becomes appropriate. high, need for a sophisticated capacity planning and scheduling function.
Product Structure Complexity	Benton and Srivastava (1985)	Measured by breadth complexity and depth complexity in the B.O.M.
	Kochhar and McGarrie (1992)	High number of levels in the B.O.M., MRP becomes necessary to facilitate the accurate explosion of the B.O.M.'s.
	De Toni, Caputo and Vinelli (1988)	Disadvantage of using ROP when managing low level components, grows in proportion to the number of levels. MRP applied when dependent demand items present, significant inventory reductions available.

	Orlicky, Plossl and Wight (1972)	Checklist for reviewing bill of material.
	Lambrecht and Van den Wijngaert (1985)	Engineering industries, MRP implemented because large number of subassembly stages and different component items per product and the wide range of end products produced.
Number of variants per product	Kochhar and McGarrie (1992)	A large number of variants per product results in the need for a good MRP system and indicates the need for modular bills of material. It also results in the complexity of all the control functions being increased, leading to difficulties in operations.
Product family categorisation	Kochhar and McGarrie (1992), Heard (1986)	Low level of product family categorisation, need for control over functions of capacity planning and scheduling, and shopfloor control is emphasised. High level, pull control becomes possible with the formation of cells becoming easier.
Degree of engineering changes	Kochhar and McGarrie (1992), Kanet (1986), Hannah (1987)	High level, and lack of disciplined engineering change procedure affects data integrity and thus the performance of all the control functions.
	Harhalakis (1986)	Classifies engineering changes into two types.
Effectivity dates	Kanet (1986)	Outlines crucial role.

Process Issues (Table 3)

Characteristic Identified	Author (s)	Contribution to literature/Criticisms
Lead Times		
Lead time accepted by customer in relation to the manufacturing lead time	Kochhar and McGarrie (1992)	Good pull control and inventory control are required to achieve the objective of short commercial lead times.
Reliability of system lead times	Gardiner, Blackstone and Cox (1993)	DBR systems usually use lead times roughly 3 times the total processing for a part. MRP systems use lead times roughly 10 times the total processing time, as evidenced by the notion that a part spends roughly 90% of its shop time in queue.
Company's delivery performance	Handfield and Pannesi (1992)	Analysis of both delivery speed and reliability.
Operation of lead time reduction program	Vastag and Whybark (1993)	Study. manufacturing lead times will increase with work in progress.
	Cusumano (1994)	Principles of lean management, Production - Toyota model.
	Christopher and Braithwaite (1989)	Concept of strategic lead time.
Production Flow		
Volume production	Kochhar and McGarrie (1992)	In low volume situations, the scheduling problem becomes more complex. whereas in high volume situations, scheduling is less complex and pull control becomes very suitable for controlling large, repetitive volumes.
	Tobias (1991)	MRP appropriate for medium/low volume high variety situations. Pull systems primarily serve high volume/low variety. For high volume, high variety, system becomes so complicated that effective control is virtually impossible. Partitioned into subsystems.
Number of manufacturing operations	Kochhar and McGarrie (1992)	With a low number of manufacturing operations and shorter routings, there is a need for simple capacity planning and scheduling and for shopfloor control. A high number increases the complexity of, and highlights the need for complex capacity planning and scheduling and shopfloor control.
Number of works orders	Kochhar and McGarrie (1992)	Large number - Indicates the need for good capacity planning and scheduling, and for shopfloor control.
Alternative routings and processes	Kochhar and McGarrie (1992)	Indicates a need for detailed capacity planning and scheduling. In such circumstances, there is an increase in the complexity of the capacity planning and scheduling, and shopfloor functions, due to an increase in the data requirements.
Set-up reduction	Oliver (1990)	Swift set-ups essential for JIT.
	Kochhar and McGarrie (1992), Sugden (1985)	Fairly short set-ups major factor when pull control systems are to be used in cellular manufacturing environments.

	Lummus and Duclus-Wilson (1992)	Reductions of only 5-10% are an indication that set-up has been overlooked in JIT implementation.
	Daniel and Reitsperger (1991)	Reductions make it economically feasible to produce increasingly smaller lot sizes, thus decreasing inventory levels, allowing flexible responses to market changes.
Cells		
Shopfloor control decentralised	Maes and Van Wassenhove (1991)	JIT relies on highly decentralised shopfloor control.
Use of cellular manufacturing	Afzulpurkar, Huq and Kurpad (1993)	Prerequisite for JIT. Applicability. Critical success factors. Performance measures.
	Daniel and Reitsperger (1991)	Reduction in complexity arising from cellular grouping.
Structured interface with rest of organisation	Prickett (1994)	Must have a structured interface. Allow cells to grow and shrink with demand. Selecting workers.
	Kochhar and McGarrie (1992)	With a high degree of cellular manufacturing, there is an obvious requirement for pull control with MRP being used to generate the requirements for parts.
	Afzulpurkar, Huq and Kurpad (1993)	Before moving to cells, need to identify constraints imposed by computer-based MPS/MRP system. Selecting workers.
Use of Group Technology	Prickett (1994)	First rule of cell design and implementation, grouping of parts into identifiable families.
	Rao and Schrenga (1987)	Physical cells or logical cells.
Minute by Minute shopfloor control	Burgoine (1988), Donovan (1990)	Biggest gap in systems like MRPII, 'what do we do next?' shopfloor decision-making.
Schedule changes	Bennett and Forrester (1994)	Reasons for changing schedules need to be identified and underlying problems resolved.
Disciplined shopfloor decision-making	Kochhar and McGarrie (1992), Hall (1986)	Necessary in order to prevent a lack of confidence in manufacturing control systems emerging in the system with the consequent proliferation in informal procedures.
Prioritisation of production orders	De Toni, Caputo and Vinelli (1988)	Priority assignment system necessary. Despatch list.
	Gelders and Van Wassenhove (1985)	Differences in MRP and JIT outlined.
Maintenance		
Machine downtime	Minifie and Davis (1986)	Increases inherent nervousness of MRP systems.
	Kochhar and McGarrie (1992)	Detrimental effect on performance of capacity planning and shopfloor control functionality.
	Gerwin (1986)	Rerouting flexibility required.
	Daniel and Reitsperger (1991)	Production interruptions.
Process design	Gallimore and Penlesky (1988)	Process facilities should be designed so that they are reliable and easy to use.
Maintenance as % of production costs	Maggard and Rhyne (1992)	Estimates of 10-40/5 of production costs, cannot be ignored.
Maintenance Strategy	Gallimore and Penlesky (1988)	Should have the ability to adapt when new equipment or model changes are incorporated into the manufacturing process.
	Maggard and Rhyne (1992)	Implementation of Total

		Productive Maintenance (TPM).
Use of kanbans	Maes and Van Wassenhove (1991)	Number of kanbans released, container sizes.
Use of dedicated JIT lines	Schonberger (1986)	Make sense when capacity is cheap and volumes are high.
Technology and Flexibility		
Production Technology	Kochhar and McGarrie (1992)	Use of AMT simplifies the capacity planning and scheduling and the shopfloor control problems by reducing the number of manufacturing operations. Helps with creation of cellular systems.

Capacity Issues (Table 4)

Characteristic Identified	Author (s)	Contribution to literature/Criticisms
Steady State Capacity	Towill, Naim and Wikner (1992)	Design guideline for planned steady state capacity.
Balance shopfloor loading with customer demand	Towill, Naim and Wikner (1992)	One of the requirements for JIT via kanban controls is shopfloor loading virtually constant in terms of volume.
Capacity expanded	Florida and Kenney (1990)	Hiring of significant number of temporary workers.
	Gelders and Van Wassenhove (1985)	JIT simply raises its overall capacity to accommodate fluctuations in demand either by increasing throughput or adding more productive cells.
Capacity changes fed back to MPS	Burcher (1992)	Cases and survey. outlines data problems with feedback to MPS.
	Gelders and Van Wassenhove (1985)	MRP and its link to capacity decisions.
Plant working at full capacity	Kochhar and McGarrie (1992)	Plant working consistently at on near full capacity, form of detailed capacity planning is required. Can cause extreme problems with data gathering and integrity.
Availability of efficiency and utilisation information	McNair (1994)	Compares traditional viewpoint of capacity management resulting in efficiency, with emerging viewpoint. resulting in effectiveness.
Use of Industrial Engineers	Chan, Samson and Sohal (1990)	Highly regarded in Japan. Part of Integrative model developed.
Rough Cut Capacity Planning	Herroelon and Lambrecht (1989)	Widespread use of RCCP may be a good capacity check at the planning stage, but in many cases this is not good enough.
Spreadsheets	Marucheck and Peterson (1988)	Outline benefits for small companies when using spreadsheets for MPS.
Theory of Constraints	Kochhar and McGarrie (1992)	High number of bottlenecks indicates need for detailed capacity planning and scheduling. OPT highlighted as helping to identify problems and scheduling the work appropriately. When the number of bottlenecks is low, there is still a need for capacity planning and shopfloor control.
	Gardiner, Blackstone and Gardiner (1993)	Outline DBR/buffer management approach to capacity planning.
	Fawcett and Pearson (1991)	Outline constraint management.

Inventory Issues (Table 5)

Characteristic Identified	Author (s)	Contribution to literature/Criticisms
Inventory Data Integrity		
Integrity of Operations Information - quality and quantity	Kochhar and McGarrie (1992), Kanet (1986), Blackstone and Cox (1985)	Data accuracy and integrity are vital to the successful implementation and operation of manufacturing control systems.
	Proud (1986)	MRP needs accurate records, B.O.M.'s, on-hand balances, and open order status's.
	Quigley (1980)	Formulated 3 tests for data accuracy for MRP.
	Pacos and Sinn (1989)	Accountability and training for accurate inventory data.
	Ptak (1991)	Large portion of total resource of system is dedicated to maintenance of accurate status within the system.
Monitoring and maintaining data	Sewell (1990)	Systems and mechanisms for control of informational interfaces.
Strict discipline and validation at input stage	Yoo (1989)	Information system cannot produce reliable output information without valid input.
	Gelders and Van Wassenhove (1985)	MRP has a virtual unavoidable susceptibility to data input error.
	Blackstone and Cox (1985)	Need discipline, which may be maintained if top management insist on it.
On-Time Retrieval and transmission	Lee and Billington (1992)	Delays, for example, in MRP execution, major problem for Supply Chain Management.
Real time data processing	Gelders and Van Wassenhove (1985)	MRP has an inherent inflexibility with its batch-oriented data processing nature. Data hungry.
	Yoo (1989)	Databases required for MRP and JIT.
Information Technology	Yoo (1989)	Information system requirements for JIT.
	Daniel and Reitsperger (1991)	Compare information provision in Just-In-Time with Just-In-Case.
	Kim (1985)	Periodic pull system where manual information processing system is replaced by on-line computerised processing.
	Kim and Schniederjans (1990)	Implementation of computer-integrated JIT production system.
Need for 100% material traceability	Kochhar and McGarrie (1992)	Need for MRP, inventory, purchasing and shopfloor control. Procedures can also be devised to provide traceability in cellular manufacturing systems.
Level of evaluation and regulation in production planning and control	Plenert (1992)	Develop model for world manufacturing information flow. Control and feedback mechanisms of MRP become complex because of elaborate systems developed to evaluate and regulate the effectiveness of each individual employee. Need routings. For effective routings, need detail history on labour performance.
Cycle-counting	Neeley (1987)	Annual physical inventory not a very good method. Advocates use of cycle-counting.

	Reichart (1976)	Main purpose is to identify sources of error, and then correction of basic problem.
	Graf (1987)	Limitations of cycle-counting.
ABC analysis	Martin and Goodrich (1987)	ABC assignments are arbitrary.
	Graff (1987)	Reasons for approach being questionable.
	Reichart (1976)	Need to be certain that all those involved in the transactions understand the need for accuracy and discipline.
Non-significant part numbers	Elliot (1987)	All part numbers should be non-significant.
Inventory Costs Falling	Natarajan (1991)	Expands famous river flow analogy.
	South and Hansen (1991)	Need a better theory that a statement that simply says all inventory is waste.
	Singh and Brar (1992)	WIP is often necessary when there is a lack of synchronisation in the flow of production.
	Daniel and Reitsperger (1991)	Uncertainties from within and outside the company when inventory is reduced.
	Dillon (1990)	Costs associated with inventory.
Look at reasons for high stock levels	Lockyer and Wynne (1989)	Reasons for long stock life.
	Toelle and Tersine (1989)	Causes of excessive inventory.
Correct assessment of inventory costs	Lee and Billington (1992)	Calculation of opportunity cost.
	Natarajan (1991)	Cause and effect diagram to organise all the information about the various factors that influence inventory costs.
High value component items	Kochhar and McGarrie (1992)	Existence of a high number of high-value items indicates the need for good inventory control and purchasing systems to minimise loss.
Order quantity research	Benton (1992)	Classifies significant literature on purchase lot sizing.
	Peek and Blackstone (1987)	Researchers have been reluctant to use Wagner-Whitin (WW) Algorithm due to lack of efficient computer implementation of the algorithm.
	Jones (1991)	Newly identified relevant carrying costs.
	Haddock and Hubicki (1989)	Reasons why implementations of MRP use simplistic approaches to establishing lot-size quantities.
	Saunders (1987)	Limitations and assumptions behind EOQ model.
	Lee and Billington (1992)	Dynamic process, uncertainties are constantly changing, inventory stocking policies should be periodically adjusted to reflect such changes.
Types of buffering	Bennett and Forrester (1994)	Tactical buffering. Means of effectively managing inventories under low volume conditions.
	Oliver (1990)	Dynamics of stock accumulation discussed.
	Maes and Van Wassenhove (1991)	Can be physical or time buffer.
	Murthy and Ma (1991)	Types of uncertainty affecting MRP, and approaches to dealing with uncertainty.
Number of inventory transactions		
	Neeley (1987)	Defines stockkeeping units (sku's) and inventory activity.

Pre-kitting	Kochhar and McGarrie (1992)	Large number of transactions indicates need for some sort of computer-based system in order to process all the data involved.
Receiving	Bennett and Forrester (1994)	Pre-kitting is non-value. Improvements outlined.
	Waples and Norris	Back-flush costing outlined.
MRP		
Use of MRP	Luscombe (1991)	Five basic principles of production control suggested.
	McManus (1989)	Development of implementation plan for MRP.
	Burns, Turnipseed and Riggs (1991)	Survey. Implementation of MRP. Factors affecting success.
	Cerveny and Scott (1989)	Degree of perceived success with MRP can vary with definition of success.
Types of MRP	Duchessi, Schaninger and Hobbs (1989)	Survey. Factors leading to successful implementation of MRP.
Inputs to MRP	Blackstone and Cox (1985)	Selection criteria for either regenerative or net change MRP.
	Vargas and Dear (1991)	Primary prerequisites for MRP. Key sources of uncertainty.
Outputs from MRP	De Toni, Caputo and Vinelli (1988)	Uncertainties which affect MRP.
	Donovan (1990)	Critical questions of manufacturing control that cannot be answered by standard MRPII.
Scheduling		
JIT	Yoo (1989)	Managerial information available from MRP.
	Lummus and Duclos-Wilson (1992)	Plants have only implemented a portion of the philosophy.
	Pegler and Kochhar (1990)	Development of JIT rule base to take interdependency into account.
	Richman and Zachary (1994)	Guidelines for implementing JIT.
	Safayeni, Purdy, Van Engelen, Pal (1991)	Classify the efforts towards JIT into 4 levels.
	Millar (1990)	Total JIT Strategic Framework.
Hybrid Systems	Fiedler, Gallently and Bicheno (1993)	Development of an expert system for JIT implementation.
Use of Hybrids	Lee (1993)	Need to accommodate best planning features of MRP and best execution features of JIT.
MPS		
MPS	Karmarkar (1989)	Most advanced manufacturing companies find that they require a hybrid system of shopfloor control systems like pull, and time-tested computer driven push systems.
Who should master schedule	White (1986)	Poorly managed, can lead to system failure.
Sources for changing MPS	Malko (1976)	Knowledge required.
	Burcher (1992)	Cases and survey into MPS practice. Remedies suggested for better MPS performance.
	Malko (1976)	Major sources for changing MPS.
	Kochhar and Suri (1992)	Issues for consideration when implementing MPS system. Knowledge based gap analysis approach for implementation help.

Workforce Issues (Table 6)

Characteristic Identified	Author (s)	Contribution to literature/Criticisms
Change Management		
Status awareness of skilled workers	Harber, Samson, Sohal, and Wirth (1990)	Influence of Japanese cultural heritage on JIT success.
Give workers broader tasks	Florida and Kenney	Develop a more comprehensive view of the production process. Allows participation in design and redesign tasks.
Planning tasks for workers	Conti and Warner (1993), Heiko (1989)	"Soikufu" (creative thinking) approach to job design.
Flexible working encouraged	Dawson and Webb (1989), Sayer (1986)	Three distinct forms of flexibility.
	Willis and Suter (1989)	Two cases, implementing JIT, flexible working resisted, need for more strategic approach to future recruitment.
	Bratton (1991)	Skill enhancement restricted to core group of skilled workers.
	Kochhar and McGarrie (1992)	The existence of a very skilled workforce is very important for the successful implementation and operation of both pull control and OPT.
	Woodcock and Weaver (1993)	Four levels of competence.
	Slack and Correa (1992)	3 levels of analysis of flexibility research.
	Mueller	Common ground of flexibility in European automobile industry.
	Parthasarthy and Sethi (1992)	Scope flexibility and speed flexibility.
Shopfloor seen as source of ideas and constant improvement innovations	Florida and Kenney	Key feature of the Japanese system, called kaizen.
Workers participate in Quality Circles	Inman and Boothe (1993)	Quality Circles not an integral part of every JIT implementation.
	Florida and Kenney (1990)	Quality Circles require a relatively stable production environment and implementation must be rather slow.
	Chan, Samson and Sohal (1990)	Differences between uses in West and in Japan.
Job Classifications	Florida and Kenney	Few job classifications for workers in Japanese plants.
Innovation and creativity	Hiltrop (1992)	Issues for minimising potentially negative effects of JIT on people. Development of an organisational climate that facilitates technological and managerial innovation and reduces resistance to change.
	Hinterhuber and Popp (1991)	Strategic leadership competence outlined. Vision.
Think strategically about management of change	Kochhar and McGarrie (1992)	Successful implementation of control systems requires that a company has the right attitude to change.
	Brown (1993)	Model of change.
	Willis and Suter (1989)	5 phases of change management in manufacturing.
	Turnipseed, Burns and Riggs (1992)	Use of classical approach to organisational change for MRP implementation.
	White and Flores (1987)	Importance of goal setting in a production environment when implementing MRP.
	Smith and Tranfield (1989)	Implementation of MRP II. Morphostatic and Morphogenic change.

Commitment to implementation	Galvin (1986)	Management support without understanding is a liability.
	Kochhar and McGarrie (1992). Heard (1986). Hartley (1983). Hall (1986)	Top management must be committed to the introduction of a new manufacturing control system. providing good support during implementation.
	Vora. Saraph and Petersen (1990)	14 JIT implementations. Top management commitment found to be only marginally followed in practice.
	Hannah (1987)	JIT. management to understand philosophy. characteristics and mindset of JIT.
	Schlussel (1990)	Critical Success Factor. MRP II Implementation. executive vision and plan.
	Helms (1990)	Commitment to JIT program by top executives helps secure individual participation.
	Keller. Kazazi and Carruthers (1992)	Most important task in JIT implementation. is the engendering of a universal culture in a company with regard to JIT at all levels from the chairman down.
Consensus Management	Chan. Samson and Sohal (1990)	Eliminating 'finger-pointing'.
Resistance to change overcome	Maes and Van Wassenhove (1991)	Resistance to change and keeping one's own private databases makes it difficult to implement MRP successfully.
Education and Training		
Education and Training	Kochhar and McGarrie (1992), Hartley (1983).	A high level of formal education and training is critical to the successful implementation and subsequent operation of a new manufacturing control system.
	Florida and Kenney	Japanese companies. firms spend large sums on employee training.
	Stewart (1991)	Problem-solving techniques in education and training programs.
	Torkzadeh and Sharma (1991)	Seminars need to be company specific.
	Ettkin (1987)	Education programs that are handed down or up without commitment from the individuals involved. are doomed to failure.
	Newman and Kirk (1986)	Rapid growth of a company implies a steady influx of new employees and the need to train them in conjunction with implementation.
	Millard (1989)	Types of training for MRP implementation. Training problems outlined.
	Schlussel (1990)	Project team education.
	Safizadeh and Raataf (1986)	Not just technical issues addressed but focus on alleviating fears related to changes in interpersonal relationships.
Timing of education and training	Kinnie (1991)	Ideally training should occur well in advance of actual JIT implementation.
	Florida and Kenney	In Japanese transplants in US, once an employee is formally hired. training commences with a 6-8 week introductory period.

Organisational Structure		
Workers trained to perform a number of tasks	Schonberger (1986)	Evolution in employee skills by taking the skill out of the job and developing the skill of the mind.
	Hiltrop (1992)	Specific training programs must be developed to ensure that workers have acquired new knowledge, skills and abilities.
	Hannah (1987)	Gradual process, enhanced by mutual trust and communication.
Person in charge of more than one function	Blackstone and Cox (1985)	Small business, one person may perform more than one function. Must have a level of understanding extending over several areas.
Accountability (competent personnel with clearly assigned responsibilities)	Waples and Norris (1989)	Related to flexibility and increased responsibility of labour.
To which operate in formal system	Safizadeh and Raataf (1986)	Extent of reliance of informal system has a major impact on the chances of succeeding with MRP.
	Maes and Van Wassenhove (1991)	Requires that all informal systems disappear and all business activities be governed through formal MRP transactions.
Interdepartmental co-ordination	Lee and Billington (1992)	Organisational barriers in supply chain.
	Kochhar and McGarrie (1992)	Increased co-ordination between manufacturing and sales/marketing is very important for good master production scheduling. Also increases possibility of success with pull control, given ownership at a low level.
	Crittenden (1992)	Mechanisms for improving interfunctional co-ordination.
	Powers, Sterling and Wolter (1988)	Main sources of conflict between marketing and manufacturing.
Flat Management Structures	Kochhar and McGarrie (1992)	Allows companies to give a quick response to problems. Delegation of authority and responsibility is particularly important for the effective implementation of cellular systems and pull control.
Capability of redesign of manufacturing systems	Kochhar and McGarrie (1992)	Especially important for the introduction of cellular manufacturing systems, and hence pull control systems.
	Gerwin (1986)	Flexibility responsiveness, achieved through the redesign of the manufacturing process.
	Tobias (1991)	Lucas approach via Task Forces.
Good Industrial Relations	Inman and Mehra (1989)	Overcoming conflict in JIT implementation.
	Florida and Kenney	Hybrid model of industrial relations in Japanese transplants in the U.S.
Job Security	Florida and Kenney	Japanese system of employment security.

Wage determination by teamwork and quality	Schonberger (1986)	No room for incentive pay plans in a World Class plant.
	Willis and Suter (1989)	Payment system for flexible working cells at Pirelli.
	Florida and Kenney	Japanese system of wage determination.
Personnel absenteeism	Kochhar and McGarrie (1992)	A low level of absenteeism is an essential consideration for pull control. The level of absenteeism also affects the operation of other types of control system.
Indirect and direct labour productivity	Oliver (1990)	JIT personal productivity improvements.

Quality Issues (Table 7)

Characteristic Identified	Author (s)	Contribution to literature/criticisms
Yield rates and 'right first time' production	Kochhar and McGarrie (1992)	All control functions are detrimentally affected by low yield and high rework. Pull control in particular is not suited when 'black-art' processes are present, or when there is a high level of rework.
Statistical Process Control (SPC)	Dale, Shaw and Owen (1990)	Implementation difficulties in automotive industry.
	Schonberger (1986)	SPC not much use in a job shop because job order quantities are usually too small to draw samples from.
Special Templates	Hannah (1987)	Alternative to following rigid variable sampling plan. Process capability studies and verification.
Poka Yoke	Chan, Samson and Sohal (1990)	Part of integrated JIT model.
Continuous Improvement Plan	Conti and Warner (1993)	Kaizen discussion.
	Schniederjans (1993)	Productivity Cycling Process
Waste Reduction program	Ajala (1992)	Categories of waste.
	McNair (1994)	Categories of waste in capacity management.

Supplier Relations Issues (Table 8)

Characteristic Identified	Author (s)	Contribution to literature/Criticisms
Supply Strategies		
Percentage of bought-out parts	Kochhar and McGarrie (1992)	Highlights need for MRP, inventory control, purchasing.
Accurate delivery status available from suppliers	Lee and Billington (1992)	Not enough attention paid to timely updates.
	Kochhar and McGarrie (1992)	Uncertainty when delivery is not on time, detrimental affect on all control functions.
Reduction in supply base	Turnbull, Delbridge, Oliver, and Wilkinson (1993)	Outline trend towards fewer, larger and more talented suppliers as sole source of supply for component systems in the automotive sector.
	Lee and Billington, (1992)	Must understand sources of uncertainty and magnitude of their impact.
Compatibility of company philosophies betwen company and supplier	Romero (1991)	Need compatibility between supplier's marketing and the buyer's supply strategies.
	Lee and Billington (1992)	Coordination is crucial as supply chains become more global.

Customer Relations Issues Characteristics

Characteristic Identified	Author (s)	Contribution to literature/Criticisms
Regularity of demand pattern from customers	Kochhar and McGarrie (1992)	Regular demand pattern essential for the smooth operation of cellular manufacturing systems, and hence use of pull control systems. Irregular demand patterns result in nervousness in the operation of all types of manufacturing control systems.
Length of product life cycles	Gerwin (1986)	Uncertainty leads to changeover flexibility, ability of process to deal with additions to and subtractions from the mix over time.
	Kochhar and McGarrie (1992)	Uncertainty affects the choice and suitability of pull control. Long-term support and maintenance of products results in pull control being most affected with cell integrity becoming more difficult to achieve.
Runners and repeaters, and strangers	Jackson and Browne, 1992	Where customised products are the norm, the popular approaches to production planning and control such as CIM and MRP, may have limited applicability.
	Kochhar and McGarrie (1992), Parnaby (1988)	Large number of strangers increases the shopfloor and capacity problems, and thus indicates the need for a degree of sophistication these functions. Small number of strangers and large number of repeaters and runners indicate suitability of a pull type of control system.

APPENDIX 3

THE CURRENT REALITY DOCUMENT

STRATEGIC ISSUES (TABLE 1)

Degree..........	Low		High
PERFORMANCE MEASURES of use of performance measures?			
to which you use a % improvement in each measure rather than absolute level?			
to which you use performance trends rather than absolute levels?			
to which you link Measures of Performance to Critical Success Factors (CSF)? (CSF - those factors which are critical for success in your industry)			
to which you use the following Measures of Performance?			
days in inventory?			
defective material?			
on time delivery ?			
past-due position?			
% completion of Master Production Schedule (MPS)?			
lead time performance?			
forecast accuracy?			

Bill of Material (BOM) accuracy?		
inventory accuracy?		
capacity utilisation?		
value-added and non-value added costs?		
part standardisation?		
cost of quality?		
set-up and changeover time?		
machine reliability?		
employee suggestions?		
to which you question the appropriateness of your current measures of performance?		
BENCHMARKING to which you use benchmarking?		
to which you benchmark your products against the competition?		
to which you benchmark your processes?		
to which you benchmark internally?		

to which you benchmark against the competition?

to which you benchmark against the best-in-class? (could be in a completely different industry but best at a particular process e.g. new product introduction)

to which you carry out strategic benchmarking? (integrates strategic competitive analysis with best-in-class)

COST CONTROL

to which budgetary control system focuses on long-term targets?

to which you use activity-based costing?

to which you use process costing?

MANUFACTURING STRATEGY

of use of a clear manufacturing /operations strategy?

to which your industry is stable in nature?

to which you compete on the basis of your quality exceeds all industry standards?

to which you compete on the basis that your products are unique?

to which you compete on the basis of having an extraordinary design capability?

to which you compete in a

non-standard product environment?		
to which your customers have certain demand?		
to which your customers' dominant competitive pressure is low cost?		
to which your customers' dominant competitive pressure is delivery performance?		
of value-adding capability within your plant?		
to which you follow the focused factory concept?		
to which you make-to-order (MTO) and/or assemble-to-order (ATO)?		
to which you ask the following questions?		
how do customers see us?		
what must we excel at?		
can we continue to improve and create value (innovation and learning perspective)?		
how do we look to shareholders (financial perspective)?		

PRODUCT ISSUES (TABLE 2)

Degree..........	Low				High
DEMAND DATA of sales forecast accuracy?					
to which you have a regular demand pattern?					
of certainty as to the length of product life cycles?					
to which can cope with revisions of customer demand?					
DESIGN to which you design with Supply Chain Management considerations in mind?					
of use of concurrent engineering (simultaneous engineering)?					
of use of Design for Manufacture (DFM) and Design for Assembly (DFA)?					
of use of Computer-Aided Design (CAD)?					
of use of modularised product designs?					
of use of planning bill of materials?					
of simplicity of your bill of materials?					
- breadth - (defined by no. of immediate components per parent in BOM)					
- depth - no. of levels in BOM					

to which you design new products on time?				
to which you introduce new products on schedule?				
of engineering changes?				
to which effectivity dates adhered to?				
to which the lead time(LT) accepted by customers is greater than the LT of your manufacturing system?.				
to which LT quoted by marketing to obtain customer orders is less than manufacturing lead time?				
of simplicity in number of variants per product?				
of runners and repeaters? (runners defined products regularly ordered - repeaters defined as products occasionally ordered)				
of ease of introducing new products?				
of product family categorisation?				
to which you don't have to support and maintain products in the long-term?				
MPS				

to which you use a Master Production Schedule?		
to which you develop the demand side of the MPS - (e.g. Available to Promise ATP/forecasting/planning bills)?		
to which you develop the supply side deficiencies of the MPS - checking validity of plans and schedules in terms of available capacity?		

PROCESS ISSUES (TABLE 3)

Degree..........	Low			High
LEAD TIMES to which have short process lead times?				
to which you operate a LT reduction program?				
of reliability of lead times?				
of which you deliver on time?				
PRODUCTION FLOW to which products flow through the shopfloor without the need to queue?				
to which process facilities are designed for reliability and ease of maintenance?				
to which you use task forces/project teams etc.for process redesign purposes.				
to which you develop new processes for old products?				
of volume production?				
to which you have few manufacturing operations?				
to which you have few shopfloor routings?				
to which you have a low number of works orders?				
to which you operate in a static/slow moving environment?				

to which you use alternative routings and processes?		
of potential production mix alternatives available to you?		
of repetitiveness of operations?		
to which you try and reduce set-up times?		
of use of a continuous improvement program?		
of your awareness of Theory of Constraints (TOC)?		
of standardisation of operations?		
CELLS of use of cellular manufacturing?		
to which shopfloor control is decentralised?		
of local performance measures being linked to global business measures?		
of use of performance measures for cellular manufacturing?		
of use of Group Technology?		
of space savings resulting from cellular manufacturing?		
of use of physical cells?		
of use of logical cells?		

to which system allows cells to grow and shrink as demand dictated with associated movement of workers across boundaries?		
of ease of selecting cell workers?		
of ease of justifying cellular manufacturing?		
to which cellular manufacture has a structured interface to rest of organisation?		
of use of standard containers on the shopfloor for material movement?		
of use of kanbans?		
of use of dedicated Just-inTime (JIT) production lines?		
MAINTENANCE of certainty of machine downtime?		
to which maintenance represents a small 0% of production costs?		
of use of Total Productive Maintenance? (some maintenance tasks allocated to operators)		
of use of a Maintenance strategy to adapt to new equipment and/or model changes?		
TECHNOLOGY AND FLEXIBILITY to which can overcome bottlenecks/constraints?		

of sequencing flexibility - ability to alter order in which parts are fed into manufacturing process?		
to which production technology is a competitive force?		
of implementation of Flexible Manufacturing System (FMS)?		
to which you can make new production technology work?		
of prioritisation of production *of particular products*?		
of disciplined shopfloor decision-making process?		
of ability to manage expediting orders?		
of ease of releasing orders?		
to which production moves through standard sequence?		
of use of despatch list?		
of use of 'minute by minute' shopfloor control?		
of availability of highly accurate and timely information on the shopfloor?		
of use of computerised information system on the shopfloor?		
of visual inspection of work?		

CAPACITY ISSUES (TABLE 4)

Degree..........	Low			High
to which you can have a planned steady state capacity?				
to which you can balance shopfloor loading with customer demand e.g. shift human resources?				
to which capacity can be expanded easily?				
of ability to measure workload in terms of standard hours?				
of use of time standards?				
of availability of routing information?				
of availability of efficiency and utilisation information allowing calculation of net 'rated' capacities?				
of use of computerised Shopfloor Data Collection System?				
to which can change capacity by subcontracting/overtime?				
to which capacity changes are fedback to Master Production Schedule?				
of usage of industrial engineers?				

of use of finite capacity planning techniques?		
of use of infinite capacity planning techniques?		
of use of Rough Cut Capacity Planning (RCCP)?		
to which plant working well below full capacity?		
of use of Capacity Requirements Planning System/Module (CRP)?		
of success with CRP?		
of use of spreadsheet packages for capacity planning?		

INVENTORY ISSUES (TABLE 5)

Degree..........	Low			High
INVENTORY DATA INTEGRITY of integrity of operations information - quality and quantity?				
of monitoring and maintaining this data?				
of strict discipline and validation at input stage?				
of on-time information retrieval and transmission?				
of real time data processing?				
of lengthy 'window' between when schedule is created and materials required at point of use?				
to which you identify reasons for changing schedules?				
of ease of coping with inventory activities - no. of transactions against a given sku per some time period?				
of correct assessment of inventory costs?				
to which access to the stockrooms is limited?				
of low value component items?				
of use of order quantity research?				

of existence of clear channel of communication between materials and accounts?		
to which Economic Batch Quantities (EBQ) uses correct estimates of input parameters to model?		
to which look at reasons for high stock levels?		
of usage of simplistic stocking policies?		
to which these policies are periodically adjusted to reflect uncertainties?		
of use of tactical buffering of stock?		
to which pre-kitting is redundant?		
of use of cycle-counting?		
of use of ABC analysis (for inventory analysis)?		
of use of fixed location storage for stock?		
of organisation of stores?		
of use of electronic stores?		
to which internal customers are treated the same as external customers?		
to which inventory costs are falling?		
of use of information technology?		

of implementation of elements of JIT?		
to which computer based information system is utilised for MEP - Major Event Planning and medium-range planning?		
to which changes in receiving procedures have required development of alternate controls e.g. backflushing?		
of use of procedural integrity design?		
to which can cope with 100% *material traceability*?		
to which working procedures are developed at the same rate as the firm is growing?		
of use of non-significant part numbers?		
MRP of use of where used lists/pegging?		
of use of medium-term 'what-if' simulations?		
of use of Materials Requirements Planning (MRP)?		
of use of net change MRP?		
of use of the outputs of MRP?		
of previous experience with MRP?		
of difficulty to do your job, if you didn't have MRP?		

of which you have more information to base decisions since MRP was introduced?		
to which you use feedback mechanisms of MRP?		
to which you have developed a production planning and control system in order to evaluate and regulate the effectiveness of each individual employee?		
SCHEDULING of availability of detail history on labour performance?		
to which critical questions can be answered by your production planning and control system?		
to which you can cope with frequent schedule changes?		
are used on a shift-to-shift basis? to which detailed scheduling strategies?		
of use of cumulative lead time?		
of certainty surrounding the inputs to production planning and control system?		
of use of buffers - safety stock - safety lead time - safety capacity - forecast inflation - hedging and overplanning - yield factor		
of use of a hybrid production planning and control system (e.g. JIT and MRP)?		

of suitability of current accounts system for the needs of manufacturing?		
MPS to which MPS is neither understated or overstated?		
of use of the following 5 major sources for changing MPS - production - shipments - performance changes - sales changes - engineering changes		
to which you have identified who should master schedule - requirements of person having being outlined?		
of level of understanding of MPS?		
of use of procedures and responsibilities for creation of MPS?		
of appropriate planning horizons/time buckets/time fences in MPS?		
of procedures for dealing with backlogs and revisions in MPS?		
of analysis behind deciding what to master schedule?		
to which have an effective contingency planning system?		

WORKFORCE ISSUES (TABLE 6)

Degree..........	Low			High
CHANGE MANAGEMENT of status awareness of skilled workers?				
to which give workers have been given broader tasks?				
to which give workers planning tasks?				
to which implement group work?				
to which have capability to redesign manufacturing systems?				
to which flexible working is encouraged in all employees?				
to which have disciplined approach to work?				
to which operate in formal system?				
of managerial innovation and creativity?				
of top management's willingness to delegate decision-making?				
of awareness that company operate in a very dynamic market, so employees are well aware of the need to continually improve the operations?				
to which one person in charge of more than one function?				

of strategic approach to future recruitment of employees?		
of need to think strategically about management of change?		
of top management commitment to implementation of production planning and control improvements (commitment with understanding)?		
of consensus management?		
to which shopfloor seen as source of ideas and constant improvement innovations?		
to which workers participate in Quality Circles?		
to which resistance to change has been overcome?		
of accountability (competent personnel with clearly assigned responsibilities)?		
to which build accountability into people's jobs?		
of labour motivation?		
EDUCATION AND TRAINING		

of education and training within the company?				
of education and training in production planning and control?				
of consideration given to timing of education and training (education and training given in advance)?				
to which workers trained to perform a number of tasks e.g. maintenance				
to which workers given a more comprehensive view of production process?				
to which workers participate in design/redesign of tasks?				
of supervisor training?				
of direct personnel training?				
of formal education and training programmes?				
of learning curve improvements?				
ORGANISATIONAL STRUCTURES of importance attached to job classifications?				

of job security?		
of wage determination by teamwork and quality?		
to which can cope with personnel absenteeism?		
to which can cope with personnel turnover?		
of payment for wide range of skills?		
of indirect and direct labour productivity?		
to which communication channels open - management and unions?		
of use of organisational integration techniques?		
of interdepartmental coordination?		
to which inventory ownership is focused?		
of use of flat management structures?		
good Industrial Relations?		

QUALITY ISSUES (TABLE 7)

Degree............	Low	-	High

of certainty with regard to yield rates and 'right first time' production?		
to which produce to quality standards?		
of use of Statistical Process Control (SPC)?		
of existence of ownership of quality (typified by development of operator certification)?		
of use of supplier to inspect at source?		
of use of special templates?		
of use of process capability studies and verification?		
of reduction in warranty and service costs?		
of use of poka yoke?		
of use of Taguchi's loss function?		
of use of waste reduction program?		

SUPPLIER RELATIONS ISSUES (TABLE 8)

Degree..........	Low	High
SUPPLY STRATEGIES		

of accurate delivery status data available from suppliers?		
of formal JIT purchasing (management has established a plan or schedule in writing)?		
of purchase expenditures committed to multi-year contracts?		
of Supply Chain Management modeling?		
to which take impact of uncertainties in the supply chain into account?		
of identification of core competencies?		
to which these core competencies are manufactured in-house?		
of compatibility of company philosophies between you and your suppliers?		
of amount of sharing of risks and rewards with suppliers?		
to which try to understand threats and opportunities that suppliers face?		
of compatibility between suppliers' marketing and the company's supply strategies?		
to which exam underlying assumptions of present company-supplier coordination?		
SOURCING TECHNIQUES		

of use of supplier associations?		
of reduction in supply base?		
to which you dominate your suppliers?		
of use of parallel sourcing?		
of use of single sourcing?		
of examination of suppliers' commercial, technical and managerial strengths when selecting suppliers?		
of analysis of process compatibility with suppliers?		
of early consultation with suppliers on design and delivery of products?		

of use of Design Approved (DA) suppliers (suppliers who will design components for you)?		
of use of Design Supplied (DS) suppliers (you supply the design for the supplier)?		
of 'grey box' system purchases (grey box - you have an idea of the physical attributes and function of the item, but do not know the details)?		
of 'black box' system purchases (you can describe what is needed only from a functional standpoint)		
of use of common components in product design?		
to which follow industry standards in purchase of components?		
to which your suppliers have a multi-market presence?		
to which purchase prices are the consequence of decisions not the initiator?		
to which recognise all costs associated with purchasing decisions?		
to which recognise some costs cannot be quantified?		
to which recognise cost premium for very frequent small deliveries?		
of use of price breaks?		

of use of specification characteristics when purchasing?		
of geographic closeness to suppliers?		
to which vehicles are suited for small JIT deliveries?		
to which suppliers have spare capacity?		
to which have compatible information systems with suppliers?		
of use of Electronic Data Interchange (EDI) with suppliers?		
to which can synchronise schedules with suppliers?		
of suppliers who have formal, disciplined systems?		
of bought-out parts?		
of use of blanket purchase orders?		
to which size buffers appropriately for your supply chain?		
to which you adjust Finished Goods Inventory for your supply chain?		
to which logistical coordination replaces inventories in your supply chain?		

to which purchasing functions objectives are clear and non-conflicting?		
of understanding that in buying, you need people with input into what they are buying and what they are producing as well?		
of reliable supplier quality?		
of non-variation sources in supply?		

CUSTOMER RELATIONS ISSUES (TABLE 9)

Degree..........	Low		High
to which you make accurate delivery status data available to your customers?			
of which you can supply your customers JIT?			
of multi-year contracts with customers?			
to which you are a first-tier supplier to customers?			

of compatibility of company philosophies between you and your customers?

of amount of sharing of risks and rewards with customers?

to which try to understand threats and opportunities that customers face?

of compatibility between your marketing strategy and your customers' supply strategies?

to which exam underlying assumptions of present company-customer coordination?

to which you are the single source of supply for your customers?

of examination your commercial, technical and managerial strengths by your customers?

of analysis of process compatibility with customers?

of early consultation with customers on design and delivery of products?

to which you are a Design Approved (DA) supplier to your customers (you design components for customer)?

to which you are a 'grey box' system supplier (grey box - you control the design detail of the system, but customers have an idea of the physical attributes and function of the item)?

to which you are a 'black box' system supplier (you control the design of the system, customer can only describe what is needed only from a functional standpoint)?

of use of common components in product design by customers for your products?

to which your customers follow industry standards in purchasing your components?

to which your customers have a multi-market presence?

to which selling prices are the consequence of decisions not the initiator?

to which customers recognise a cost premium for very frequent small deliveries?

of use of specification characteristics by customers when purchasing from you?

of geographic closeness to customers?

to which have compatible information systems with customers?		
of use of Electronic Data Interchange (EDI) with customers?		
to which can synchronise schedules with customers?		
of customers who have formal, disciplined systems?		
to which you supply customers on a call-off basis?		
to which you supply reliable quality products to your customers?		
of certainty of products accepted by customers?		
of certainty of product attributes wanted by customers?		
of certainty with regard to the amount of customer demand?		
to which build near customers?		

APPENDIX 4

EXAMPLE OF RATIONALE FOR INCLUSION

Example of the Use of the Rationale for Inclusion

The work of Lee and Billington [100] is used as an illustration of the Rationale for Inclusion part of the framework. Thus, if the Current Reality Phase was to highlight problems in the supply chain, then the following extract could be discussed with the management of the company concerned. The objective is not to automatically apply all of the principles listed for a particular Rationale for Inclusion, but instead, to discuss with management, what aspects could be applied to their company. As part of the user-led objective of the framework, the particular extract in question can be used to design an education session or seminar.

Common Pitfalls in Managing Supply Chains

(Lee and Billington)

1) no supply chain metrics.

Each with own objectives - may have little to do with supply chains overall performance. Objectives may conflict. Those that do have metrics often do not monitor them regularly. Or their metrics are not directly related to customer satisfaction e.g. measure inventory turns but do not measure response time or service fill rates to customer. Supply chain metrics must be oriented to customer satisfaction.

2) inadequate definition of customer service.

A supply chain must ultimately be measured by its responsiveness to customers. Different definitions of responsive customer service. Most companies measure *average line item fill rate (% of line item requests shipp*ed prior to customer due dates). There are variations such as weighting fill rates by £ volume). Measuring order fill rates will not itself diagnose operational problems. Conventional fills inadequately measure the degree of order lateness. Two supply chains with 90% fill may drastically differ on how promptly they fill the remaining 10%. Other critical service measures are often not tracked. These include total order cycle time or total response time to an order- average backorder levels- average lateness or earliness of orders relative to customer due dates.- backorder profile e.g. backorders 1 week late, 2 weeks late etc.

3) inaccurate delivery status data

Do not understate the significance of on time delivery, but contend that not enough attention is paid to providing customers with timely and accurate updates on the status of late orders. The consequence is dissatisfaction, confusion and loss of goodwill. Take too long to deliver a quote.

4) Inefficient information systems

Delays in information retrieval and transmission. Execution of MRP usually takes a long time. This entire process forced the manufacturer to plan monthly. Long planning cycles increase forecast errors and reduce manufacturing's ability to respond to updated order information. Manufacturing ends up building the wrong products. This leads to high inventory levels and high backorder levels.

A major computer manufacturer has its multiple sites using 12 different versions of MRP systems that are not compatible with one another.

5) ignoring the impact of uncertainties

Supply chain managers must understand their sources and the magnitude of their impact. It is surprising that many supply chains do not document and track these variables. JIT has lead to supplier performance. Little is known about transit times, specifically lead time from distribution to customers. Too often when an order leaves the dock, management considers the job complete. Transportation technology has reduced delivery time, but some variability still exists. Such information is critical for companies evaluating different modes of transportation. Federal Express - can use information to understand delivery cycles. Some companies respond well to uncertainties but fail to work on ways to eliminate them.

6) simplistic inventory stocking policies

Use information in 5 to drive inventory stocking policies. Dynamic process - the uncertainties are constantly changing. Inventory stocking policies should be periodically adjusted to reflect such changes. Companies commonly use generic stocking policies e.g. all A's - 3 weeks safety stocks, B 4 weeks etc. This classification of items by transaction volume does not necessarily reflect the magnitude of uncertainties in supply and demand. More rigorous techniques should be used.

7) discrimination against internal customers

No explicit customer service measures for internal customers

8) poor coordination

As the supply chain becomes more globalized, coordination is more critical.

9) incomplete shipment methods analysis

Changing the mode of transportation can significantly affect inventory investment and service performance. Transportation decisions are often based on economic considerations that do not take into account these important operational factors. Redesigning product packaging to make air shipment more attractive.

10) incorrect assessment of inventory costs

How should the opportunity cost of inventory be valued?

Should include opportunity cost of capital, warehousing and storage.

11) organisational barriers

Disagreements on inventory ownership and unwillingness to commit resources to help someone else.

Large manufacturing companies have decentralised organisational structures. Such decentralisation often creates these types of barriers to more integrated inventory control.

12) product-process design without supply chain consideration

NPI fast and precise manufacturing and assembly - implications for supply chain inventory are usually ignored or poorly understood. Anticipated savings may be lost owing to increased distribution and inventory costs. Need NPI and proper supply chain planning - problems created could be - product unavailability - excessive long delivery lead times- unnecessary expediting costs which may ultimately affect the product's success.

International - distribution centres can add country specific components Design for SCM can be a powerful concept for NPI. Design may be more expensive but provided much greater flexibility for meeting demand. Flexibility is especially important for a new product, whose demand could be highly variable as well as unpredictable.

13) separation of supply chain design from operational decisions

Typically fixed costs when adding or closing a plant or distribution centre. The effects of the network change on operational efficiency factors such as inventory investment and order response time are often an afterthought.

14) incomplete supply chain

Incorporating dealers - dealers inventory control systems determine to a large extent their reorder patterns, that is, frequency, size and composition.

APPENDIX 5

GENERAL QUESTIONNAIRE

GENERAL QUESTIONNAIRE FOR INITIAL SITE VISITS

My background

Framework

Free consultancy type report - my strengths

* Selection and Implementation

* SCM Current Reality - management grief issues
  Ideal
  Strategy

* Matrix

* Positioning model

Part of a Group

ANNUAL REPORT
BROCHURE

No. of Employees

Annual Sales Turnover

Make to Order/ Make to Stock/ Assemble

% Purchased items

Demand pattern/forecasting

Order Winning/Order Qualifying criteria

MRP/MRP II - ROP/INV/CAP/MATS/JIT/MPS - main problems
- status (imp.)

Focus/core competence

Customers - main, their problems, no., interface

Position in chain

Suppliers - no., sophistication level, relationship, delivering on time

Complexity of products - no of components
NPI
Product requirements e.g. stylish
Design rigourness - DFM, concurrent etc.
Product range - no. of variants
Runners/repeaters/strangers
PLC's + after-sales support and maintenance + process planning changes
Traceability
Value of items - products and bought-in
Families
Engineering changes - and impact on purchasing

Volumes
No of operations per typical product
Works orders - no. of

Lead times - meeting them, customers prepared to wait

Costing - accuracy, overhead allocation, ABC

Stores, locked etc. cycle-counting

Strategy

Top management commitment
Interdepartmental conflict - co-operation - no. of departments
E & T
Attitudes to change
Disciplines and Procedures
Data accuracy
Project management skills
Accountability
Management of change process
Demonstrable change
Any major change taking place at present

MOPS/Benchmarking

Quality - yield/rework/SPC/TQM/inspection/PPM

Shopfloor - layout - LBU's, cells, customer-focused, one planner per unit.
Bottlenecks
Alternate processes
Technology
Machine breakdown/absenteeism
Set-ups
Transactions
Skilled workforce/education level of workforce/redesign of manuf.
'Black-hole' syndrome - WIP
Lean

Organisational structure - flat
Unions/employee relations
Direct/indirect employees

Computer hardware/software choice

APPENDIX 6

CURRENT REALITY AUDIT DOCUMENT

COMPANY A

CURRENT REALITY AUDIT DOCUMENT - COMPANY A

STRATEGIC ISSUES (TABLE 1)

Degree..........	Low				High
PERFORMANCE MEASURES of use of performance measures?	* 37-50				
to which you use a % improvement in each measure rather than absolute level?	*				
to which you use performance trends rather than absolute levels?	*				
to which you link Measures of Performance to Critical Success Factors (CSF)? (CSF - those factors which are critical for success in your industry)	*				
to which you use the following Measures of Performance?					
days in inventory?	*				
defective material?	*				
on time delivery ?	*				
past-due position?	*				
% completion of Master Production Schedule (MPS)?	*				
lead time performance?	*				

forecast accuracy?	*				
Bill of Material (BOM) accuracy?	*				
inventory accuracy?	*				
capacity utilisation?	*				
value-added and non-value added costs?	*				
part standardisation?	*				
cost of quality?	*				
set-up and changeover time?	*				
machine reliability?	*				
employee suggestions?	*				
to which you question the appropriateness of your current measures of performance?	*				
BENCHMARKING					
to which you use benchmarking?			*		
to which you benchmark your products against the competition?			*		
to which you benchmark your processes?		*			
to which you benchmark			*		

internally?					
to which you benchmark against the competition?			*		
to which you benchmark against the best-in-class? (could be in a completely different industry but best at a particular process e.g. new product introduction)			*		
to which you carry out strategic benchmarking? (integrates strategic competitive analysis with best-in-class)		*			
COST CONTROL to which budgetary control system focuses on long-term targets?	*				
to which you use activity-based costing?	*				
to which you use process costing?	*				
MANUFACTURING STRATEGY of use of a clear manufacturing /operations strategy?	*32				
to which your industry is stable in nature?	*				
to which you compete on the basis of your quality exceeds all industry standards?	*				
to which you compete on the basis that your products are unique?	*				
to which you compete on the basis of having an extraordinary design capability?	*				

to which you compete in a non-standard product environment?	*			
to which your customers have certain demand?	*			
to which your customers' dominant competitive pressure is low cost?	*			
to which your customers' dominant competitive pressure is delivery performance?	*			
of value-adding capability within your plant?	*			
to which you follow the focused factory concept?	*			
to which you make-to-order (MTO) and/or assemble-to-order (ATO)?			*	
to which you ask the following questions?				
how do customers see us?	*			
what must we excel at?	*			
can we continue to improve and create value (innovation and learning perspective)?	*			
how do we look to shareholders (financial perspective)?	*			

TABLE 2 - PRODUCT ISSUES

Degree..........	Low				High
DEMAND DATA of sales forecast accuracy?		*			
to which you have a regular demand pattern?	*				
of certainty as to the length of product life cycles?			*		
to which can cope with revisions of customer demand?	*				
DESIGN to which you design with Supply Chain Management considerations in mind?	*33				
of use of concurrent engineering (simultaneous engineering)?	*33				
of use of Design for Manufacture (DFM) and Design for Assembly (DFA)?	* 33				
of use of Computer-Aided Design (CAD)?	*6				
of use of modularised product designs?	*				
of use of planning bill of materials?	*				
of simplicity of your bill of materials?	*				
- breadth - (defined by no. of immediate components per parent in BOM)			*		
- depth - no. of levels in BOM		*			

to which you design new products on time?	*			
to which you introduce new products on schedule?	*			
of engineering changes?	*4			
to which effectivity dates adhered to?	*4			
to which the lead time(LT) accepted by customers is greater than the LT of your manufacturing system?.	*			
to which LT quoted by marketing to obtain customer orders is less than manufacturing lead time?	*			
of simplicity in number of variants per product?		*		
of runners and repeaters? (runners defined products regularly ordered - repeaters defined as products occasionally ordered)			*	
of ease of introducing new products?	*			
of product family categorisation?	*			
to which you don't have to support and maintain products in the long-term?			*	
Master Production Schedule				

to which you use a Master Production Schedule?			*	
to which you develop the demand side of the MPS - (e.g. Available to Promise ATP/forecasting/planning bills)?		*		
to which you develop the supply side deficiencies of the MPS - checking validity of plans and schedules in terms of available capacity?		*		

PROCESS ISSUES (TABLE 3)

Degree.........	Low				High
LEAD TIMES to which have short process lead times?		*			
to which you operate a LT reduction program?		*			
of reliability of lead times?		*			
of which you deliver on time?	*				
PRODUCTION FLOW to which products flow through the shopfloor without the need to queue?			*		
to which process facilities are designed for reliability and ease of maintenance?			*		
to which you use task forces/project teams etc.for process redesign purposes.		*			
to which you develop new processes for old products?		*			
of volume production?		*			
to which you have few manufacturing operations?			*		
to which you have few shopfloor routings?		*			
to which you have a low number of works orders?		*			
to which you operate in a static/slow moving environment?			*		

to which you use alternative routings and processes?		*		
of potential production mix alternatives available to you?			*	
of repetitiveness of operations?			*	
to which you try and reduce set-up times?	*			
of use of a continuous improvement program?		*		
of your awareness of Theory of Constraints (TOC)?	*			
of standardisation of operations?		*		
CELLS				
of use of cellular manufacturing?		*		
to which shopfloor control is decentralised?		*		
of local performance measures being linked to global business measures?	*			
of use of performance measures for cellular manufacturing?	*			
of use of Group Technology?	*			
of space savings resulting from cellular manufacturing?		*		
of use of physical cells?	*			
of use of logical cells?	*			

to which system allows cells to grow and shrink as demand dictated with associated movement of workers across boundaries?		*			
of ease of selecting cell workers?		*			
of ease of justifying cellular manufacturing?		*			
to which cellular manufacture has a structured interface to rest of organisation?		*			
of use of standard containers on the shopfloor for material movement?			*		
of use of kanbans?		*			
of use of dedicated Just-inTime (JIT) production lines?		*			
MAINTENANCE of certainty of machine downtime?			*		
to which maintenance represents a small 0% of production costs?			*		
of use of Total Productive Maintenance? (some maintenance tasks allocated to operators)		*			
of use of a Maintenance strategy to adapt to new equipment and/or model changes?		*			
TECHNOLOGY AND FLEXIBILITY to which can overcome bottlenecks/constraints?			*		

of sequencing flexibility - ability to alter order in which parts are fed into manufacturing process?		*		
to which production technology is a competitive force?			*	
of implementation of Flexible Manufacturing System (FMS)?		*		
to which you can make new production technology work?			*	
of prioritisation of production of particular products?			*	
of disciplined shopfloor decision-making process?	*			
of ability to manage expediting orders?			*	
of ease of releasing orders?			*	
to which production moves through standard sequence?			*	
of use of despatch list?				*
of use of 'minute by minute' shopfloor control?		*		
of availability of highly accurate and timely information on the shopfloor?		*		
of use of computerised information system on the shopfloor?		*		
of visual inspection of work?			*	

CAPACITY ISSUES (TABLE 4)

Degree..........	Low				High
to which you can have a planned steady state capacity?			*		
to which you can balance shopfloor loading with customer demand e.g. shift human resources?				*	
to which capacity can be expanded easily?			*		
of ability to measure workload in terms of standard hours?		*			
of use of time standards?		*			
of availability of routing information?		*			
of availability of efficiency and utilisation information allowing calculation of net 'rated' capacities?		*			
of use of computerised Shopfloor Data Collection System?		*			
to which can change capacity by subcontracting/overtime?			*		
to which capacity changes are fedback to Master Production Schedule?		*			
of usage of industrial engineers?			*		

of use of finite capacity planning techniques?		*		
of use of infinite capacity planning techniques?			*	
of use of Rough Cut Capacity Planning (RCCP)?		*		
to which plant working well below full capacity?				*
of use of Capacity Requirements Planning System/Module (CRP)?		*		
of success with CRP?		*		
of use of spreadsheet packages for capacity planning?			*	

INVENTORY ISSUES (TABLE 5)

Degree..........	Low				High
INVENTORY DATA INTEGRITY of integrity of operations information - quality and quantity?	*19				
of monitoring and maintaining this data?		*			
of strict discipline and validation at input stage?	*11				
of on-time information retrieval and transmission?		*			
of real time data processing?		*			
of lengthy 'window' between when schedule is created and materials required at point of use?		*			
to which you identify reasons for changing schedules?		*			
of ease of coping with inventory activities - no. of transactions against a given sku per some time period?		*			
of correct assessment of inventory costs?	*14				
to which access to the stockrooms is limited?	*				
of low value component items?				*	
of use of order quantity research?		*			

of existence of clear channel of communication between materials and accounts?	*			
to which Economic Batch Quantities (EBQ) uses correct estimates of input parameters to model?		*		
to which look at reasons for high stock levels?	*15			
of usage of simplistic stocking policies?		*		
to which these policies are periodically adjusted to reflect uncertainties?	*21			
of use of tactical buffering of stock?		*		
to which pre-kitting is redundant?			*	
of use of cycle-counting?	*14			
of use of ABC analysis (for inventory analysis)?	*18			
of use of fixed location storage for stock?	*9,12,17			
of organisation of stores?	*20			
of use of electronic stores?			*	
to which internal customers are treated the same as external customers?			*	
to which inventory costs are falling?		*		
of use of information technology?			*	

of implementation of elements of JIT?		*		
to which computer based information system is utilised for MEP - Major Event Planning and medium-range planning?		*		
to which changes in receiving procedures have required development of alternate controls e.g. backflushing?	*1			
of use of procedural integrity design?	*7-13,1,8			
to which can cope with 100% material traceability?	*			
to which working procedures are developed at the same rate as the firm is growing?	*			
of use of non-significant part numbers?	*			
MRP of use of where used lists/pegging?		*		
of use of medium-term 'what-if' simulations?		*		
of use of Materials Requirements Planning (MRP)?		*		
of use of net change MRP?		*		
of use of the outputs of MRP?			*	
of previous experience with MRP?	*			
of difficulty to do your job, if you didn't have MRP?	*			

of which you have more information to base decisions since MRP was introduced?	*				
to which you use feedback mechanisms of MRP?		*			
to which you have developed a production planning and control system in order to evaluate and regulate the effectiveness of each individual employee?			*		
SCHEDULING of availability of detail history on labour performance?		*			
to which critical questions can be answered by your production planning and control system?		*			
to which you can cope with frequent schedule changes?		*			
are used on a shift-to-shift basis? to which detailed scheduling strategies?			*		
of use of cumulative lead time?		*			
of certainty surrounding the inputs to production planning and control system?		*			
of use of buffers					
- safety stock		*			
- safety lead time		*			
- safety capacity		*			
- forecast inflation		*			
- hedging and overplanning		*			
- yield factor		*			
of use of a hybrid production planning and control system (e.g. JIT and MRP)?		*			

of suitability of current accounts system for the needs of manufacturing?		*		
MPS				
to which MPS is neither understated or overstated?		*		
of use of the following 5 major sources for changing MPS				
- production			*	
- shipments			*	
- performance changes			*	
- sales changes			*	
- engineering changes			*	
to which you have identified who should master schedule - requirements of person having being outlined?	*34.35			
of level of understanding of MPS?		*		
of use of procedures and responsibilities for creation of MPS?		*		
of appropriate planning horizons/time buckets/time fences in MPS?			*	
of procedures for dealing with backlogs and revisions in MPS?			*	
of analysis behind deciding what to master schedule?		*		
to which have an effective contingency planning system?			*	

WORKFORCE ISSUES (TABLE 6)

Degree..........	Low				High
CHANGE MANAGEMENT of status awareness of skilled workers?		*			
to which give workers have been given broader tasks?			*		
to which give workers planning tasks?		*			
to which implement group work?		*			
to which have capability to redesign manufacturing systems?		*			
to which flexible working is encouraged in all employees?		*			
to which have disciplined approach to work?	*				
to which operate in formal system?	*				
of managerial innovation and creativity?		*			
of top management's willingness to delegate decision-making?		*			
of awareness that company operate in a very dynamic market, so employees are well aware of the need to continually improve the operations?			*		
to which one person in charge of more than one function?				*	

of strategic approach to future recruitment of employees?	*26			
of need to think strategically about management of change?	*			
of top management commitment to implementation of production planning and control improvements (commitment with understanding)?	*			
of consensus management?		*		
to which shopfloor seen as source of ideas and constant improvement innovations?		*		
to which workers participate in Quality Circles?			*	
to which resistance to change has been overcome?	*			
of accountability (competent personnel with clearly assigned responsibilities)?	*			
to which build accountability into people's jobs?	*			
of labour motivation?		*		
EDUCATION AND TRAINING				

of education and training within the company?	*25		
of education and training in production planning and control?	*25		
of consideration given to timing of education and training (education and training given in advance)?	*25		
to which workers trained to perform a number of tasks e.g. maintenance		*	
to which workers given a more comprehensive view of production process?		*	
to which workers participate in design/redesign of tasks?		*	
of supervisor training?		*	
of direct personnel training?		*	
of formal education and training programmes?	*25		
of learning curve improvements?		*	
ORGANISATIONAL STRUCTURES of importance attached to job classifications?	*26,27		

of job security?			*	
of wage determination by teamwork and quality?		*		
to which can cope with personnel absenteeism?		*		
to which can cope with personnel turnover?			*	
of payment for wide range of skills?	*28			
of indirect and direct labour productivity?		*		
to which communication channels open - management and unions?				*
of use of organisational integration techniques?	*			
of interdepartmental coordination?	*29,30,31,34,36			
to which inventory ownership is focused?		*		
of use of flat management structures?				*
good Industrial Relations?				*

QUALITY ISSUES (TABLE 7)

Degree...........	Low				High
of certainty with regard to yield rates and 'right first time' production?	*5				
to which produce to quality standards?	*2,3				
of use of Statistical Process Control (SPC)?		*			
of existence of ownership of quality (typified by development of operator certification)?		*			
of use of supplier to inspect at source?		*			
of use of special templates?		*			
of use of process capability studies and verification?		*			
of reduction in warranty and service costs?		*			
of use of poka yoke?		*			
of use of Taguchi's loss function?		*			
of use of waste reduction program?		*			

SUPPLIER RELATIONS ISSUES (TABLE 8)

Degree..........	Low				High
SUPPLY STRATEGIES of accurate delivery status data available from suppliers?	*22				
of formal JIT purchasing (management has established a plan or schedule in writing)?	*24				
of purchase expenditures committed to multi-year contracts?	*24				
of Supply Chain Management modeling?	*24				
to which take impact of uncertainties in the supply chain into account?	*24				

of identification of core competencies?		*	
to which these core competencies are manufactured in-house?		*	
of compatibility of company philosophies between you and your suppliers?	*24		
of amount of sharing of risks and rewards with suppliers?	*24		
to which try to understand threats and opportunities that suppliers face?	*24		
of compatibility between suppliers' marketing and the company's supply strategies?	*24		
to which exam underlying assumptions of present company-supplier coordination?	*24		
SOURCING TECHNIQUES			

of use of supplier associations?	*				
of reduction in supply base?	*				
to which you dominate your suppliers?		*			
of use of parallel sourcing?	*				
of use of single sourcing?	*				
of examination of suppliers' commercial, technical and managerial strengths when selecting suppliers?	*				
of analysis of process compatibility with suppliers?	*				
of early consultation with suppliers on design and delivery of products?	*				

of use of Design Approved (DA) suppliers (suppliers who will design components for you)?		*		
of use of Design Supplied (DS) suppliers (you supply the design for the supplier)?		*		
of 'grey box' system purchases (grey box - you have an idea of the physical attributes and function of the item, but do not know the details)?		*		
of 'black box' system purchases (you can describe what is needed only from a functional standpoint)		*		
of use of common components in product design?	*			
to which follow industry standards in purchase of components?			*	
to which your suppliers have a multi-market presence?			*	
to which purchase prices are the consequence of decisions not the initiator?		*		
to which recognise all costs associated with purchasing decisions?			*	
to which recognise some costs cannot be quantified?		*		
to which recognise cost premium for very frequent small deliveries?			*	
of use of price breaks?				*

of use of specification characteristics when purchasing?		*		
of geographic closeness to suppliers?	*			
to which vehicles are suited for small JIT deliveries?			*	
to which suppliers have spare capacity?		*		
to which have compatible information systems with suppliers?	*24			
of use of Electronic Data Interchange (EDI) with suppliers?	*24			
to which can synchronise schedules with suppliers?	*24			
of suppliers who have formal, disciplined systems?		*		
of bought-out parts?	*			
of use of blanket purchase orders?			*	
to which size buffers appropriately for your supply chain?	*24			
to which you adjust Finished Goods Inventory for your supply chain?	*24			
to which logistical coordination replaces inventories in your supply chain?	*24			

to which purchasing functions objectives are clear and non-conflicting?		*	
of understanding that in buying, you need people with input into what they are buying and what they are producing as well?		*	
of reliable supplier quality?	*23		
of non-variation sources in supply?	*		

CUSTOMER RELATIONS ISSUES (TABLE 9)

Degree..........	Low			High
to which you make accurate delivery status data available to your customers?	*			
of which you can supply your customers JIT?	*			
of multi-year contracts with customers?		*		
to which you are a first-tier supplier to customers?				*
of compatibility of company philosophies between you and your customers?			*	
of amount of sharing of risks and rewards with customers?		*		
to which try to understand threats and opportunities that customers face?			*	
of compatibility between your marketing strategy and your customers' supply strategies?			*	
to which exam underlying assumptions of present company-customer coordination?			*	

to which you are the single source of supply for your customers?				*
of examination your commercial, technical and managerial strengths by your customers?		*		
of analysis of process compatibility with customers?		*		
of early consultation with customers on design and delivery of products?	*			
to which you are a Design Approved (DA) supplier to your customers (you design components for customer)?			*	
to which you are a 'grey box' system supplier (grey box - you control the design detail of the system, but customers have an idea of the physical attributes and function of the item)?			*	
to which you are a 'black box' system supplier (you control the design of the system, customer can only describe what is needed only from a functional standpoint)?		*		
of use of common components in product design by customers for your products?	*			
to which your customers follow industry standards in purchasing your components?			*	
to which your customers have a multi-market presence?				*

to which selling prices are the consequence of decisions not the initiator?			*		
to which customers recognise a cost premium for very frequent small deliveries?				*	
of use of specification characteristics by customers when purchasing from you?				*	
of geographic closeness to customers?			*		
to which have compatible information systems with customers?		*			
of use of Electronic Data Interchange (EDI) with customers?		*			
to which can synchronise schedules with customers?			*		
of customers who have formal, disciplined systems?				*	
to which you supply customers on a call-off basis?			*		
to which you supply reliable quality products to your customers?		*			
of certainty of products accepted by customers?			*		
of certainty of product attributes wanted by customers?			*		
of certainty with regard to the amount of customer demand?	*				
to which build near customers?			*		

APPENDIX 7

EDUCATION PROGRAMME FOR COMPANY A

Education program - 4 weeks - 2 hours twice per week per person
2 groups of 7.

1 - general overview presentation

need for a new computer system
approach to be taken

2 - importance of data accuracy, particularly inventory accuracy

3 - integrated system modules x2
the individual modules of such a system, and how they combine to form a fully integrated system.. Modules - MPS, MRP, Inventory control, purchasing, capacity planning, shopfloor control, and pull control/Jit production.

4- implementation
problems - attitudes to change
inter-departmental co-operation
data accuracy
accountability
disciplines and procedures
project management
pilot implementations

5 - change management
softer issues
importance of problem solving

APPENDIX 8

SOFTWARE EVALUATION CRITERIA FOR COMPANY A

Selecting Software and Hardware

Software Evaluation Criteria.

a) Follow industry standards
-Application features, operating systems, language and communication protocols

b) Verify the system is proven in operation
-Can a normal person learn the system from the documentation.
-Does it completely describe how the system functions.
-Verify with users.

c) Investigate the potential for growth and upgrades. Over time, inflexibility of computer systems can inhibit growth. The system must be able to adequately support increased transaction and more sophisticated procedures. Fourth generation programming tools allow relatively simple modifications.

d) Immediate hot-line support
Local product consulting and support available

e) Viability of Vendor Organisation
-Growing and profitable
-High customer service reputation
-Quality product

They should be able to provide references that point to a successful track record with their former clients.

Hardware Evaluation Criteria.

1. Standard Operating Systems Support
2. Viability of Vendor Organisation
3. Provide hardware growth path
4. Good technical and service reputation.

It can be very successful for the project team to communicate with a consultant who does not try to impose big business methodology on the team.

CHECKLIST FOR USERS OF VENDOR A and VENDOR B

General questions

General problems experienced by the user site?

How severe were these problems?

What caused these problems?

How were these problems remedied?

What are the main concerns expressed by Company A staff, and did this site have to deal with the same problems?

Were any additional costs incurred?

Implementation Questions

How long did the implementation take?

Eases of implementation?

Level of support from software supplier during implementation?

Use of a project team and steering committee?

Use of a pilot?

If a pilot was used, knowledge and experience gained from it?

Quality of education and training?

Level of plant disruption during the implementation?

Operational Questions

Extent of file contentions during day to day operation?

MRP run time?

Reliability of hardware?

Reliability of software?

Level of support of software?

Level of support of hardware?

How good at providing modifications/enhancements to the system?

Any additional cost to these changes?

User-friendly documentation?

Any hidden costs incurred yearly?

Ability to link to other computer systems and software?

Summary Question

User site's overall impression of the system?

APPENDIX 9

CURRENT REALITY AUDIT DOCUMENT

COMPANY B

CURRENT REALITY AUDIT DOCUMENT - COMPANY B

STRATEGIC ISSUES (TABLE 1)

Degree.........	Low				High
PERFORMANCE MEASURES of use of performance measures?				*	
to which you use a % improvement in each measure rather than absolute level?			*		
to which you use performance trends rather than absolute levels?					*
to which you link Measures of Performance to Critical Success Factors (CSF)? (CSF - those factors which are critical for success in your industry)				*	
to which you use the following Measures of Performance?					
days in inventory?					*
defective material?					*
on time delivery ?					*
past-due position?					*
% completion of Master Production Schedule (MPS)?			*		
lead time performance?		*			
forecast accuracy?	*				
Bill of Material (BOM) accuracy?	*				
inventory accuracy?			*		

capacity utilisation?					
value-added and non-value added costs?	*				
part standardisation?					*
cost of quality?					*
set-up and changeover time?					
machine reliability?			*		
employee suggestions?				*	
to which you question the appropriateness of your current measures of performance?					*
BENCHMARKING to which you use benchmarking?			*		
to which you benchmark your products against the competition?				*	
to which you benchmark your processes?		*		*	
to which you benchmark internally?			*		
to which you benchmark against the competition?				*	
to which you benchmark against the best-in-class? (could be in a completely different industry but best at a particular process e.g. new product introduction)					
to which you carry out strategic benchmarking? (integrates					

strategic competitive analysis with best-in-class)		*			
COST CONTROL to which budgetary control system focuses on long-term targets?			*		
to which you use activity-based costing?			*		
to which you use process costing?					
MANUFACTURING STRATEGY of use of a clear manufacturing /operations strategy?					*
to which your industry is stable in nature?				*	
to which you compete on the basis of your quality exceeds all industry standards?		*			
to which you compete on the basis that your products are unique?		*			
to which you compete on the basis of having an extraordinary design capability?	*				
to which you compete in a non-standard product environment?	*				
to which your customers have certain demand?				*	
to which your customers' dominant competitive pressure is low cost?				*	
to which your customers' dominant competitive pressure				*	

is delivery performance?				
of value-adding capability within your plant?		*		
to which you follow the focused factory concept?				*
to which you make-to-order (MTO) and/or assemble-to-order (ATO)?			*	
to which you ask the following questions?				
how do customers see us?			*	
what must we excel at?				*
can we continue to improve and create value (innovation and learning perspective)?				*
how do we look to shareholders (financial perspective)?			*	

PRODUCT ISSUES (TABLE 2)

Degree...........	Low				High
DEMAND DATA of sales forecast accuracy?				*	
to which you have a regular demand pattern?				*	
of certainty as to the length of product life cycles?					*
to which can cope with revisions of customer demand?				*	
DESIGN to which you design with Supply Chain Management considerations in mind?		*			
of use of concurrent engineering (simultaneous engineering)?			*		
of use of Design for Manufacture (DFM) and Design for Assembly (DFA)?			*		
of use of Computer-Aided Design (CAD)?				*	
of use of modularised product designs?		*			
of use of planning bill of materials?		*			
of simplicity of your bill of materials?			*		
- breadth - (defined by no. of immediate components per parent in BOM)					*
- depth - no. of levels in BOM		*			

to which you design new products on time?	*				
to which you introduce new products on schedule?			*		
of engineering changes?					*
to which effectivity dates adhered to?				*	
to which the lead time(LT) accepted by customers is greater than the LT of your manufacturing system?.		*			
to which LT quoted by marketing to obtain customer orders is less than manufacturing lead time?				*	
of simplicity in number of variants per product?				*	
of runners and repeaters? (runners defined products regularly ordered - repeaters defined as products occasionally ordered)			*		
of ease of introducing new products?	*				
of product family categorisation?				*	
to which you don't have to support and maintain products in the long-term?	*				
MPS					

to which you use a Master Production Schedule?		*
to which you develop the demand side of the MPS - (e.g. Available to Promise ATP/forecasting/planning bills)?	*	
to which you develop the supply side deficiencies of the MPS - checking validity of plans and schedules in terms of available capacity?	*	

PROCESS ISSUES (TABLE 3)

Degree..........	Low				High
LEAD TIMES					
to which have short process lead times?					*
to which you operate a LT reduction program?					*
of reliability of lead times?					*
of which you deliver on time?					*
PRODUCTION FLOW					
to which products flow through the shopfloor without the need to queue?					*
to which process facilities are designed for reliability and ease of maintenance?			*		
to which you use task forces/project teams etc.for process redesign purposes.				*	
to which you develop new processes for old products?					*
of volume production?				*	
to which you have few manufacturing operations?				*	
to which you have few shopfloor routings?					*
to which you have a low number of works orders?			*		
to which you operate in a static/slow moving environment?		*			

to which you use alternative routings and processes?		*			
of potential production mix alternatives available to you?		*			
of repetitiveness of operations?			*		
to which you try and reduce set-up times?					*
of use of a continuous improvement program?					*
of your awareness of Theory of Constraints (TOC)?				*	
of standardisation of operations?					*
CELLS of use of cellular manufacturing?					*
to which shopfloor control is decentralised?					*
of local performance measures being linked to global business measures?					*
of use of performance measures for cellular manufacturing?					*
of use of Group Technology?			*		
of space savings resulting from cellular manufacturing?					*
of use of physical cells?					*
of use of logical cells?				*	

to which system allows cells to grow and shrink as demand dictated with associated movement of workers across boundaries?			*		
of ease of selecting cell workers?				*	
of ease of justifying cellular manufacturing?					*
to which cellular manufacture has a structured interface to rest of organisation?				*	
of use of standard containers on the shopfloor for material movement?		*			
of use of kanbans?		*			
of use of dedicated Just-inTime (JIT) production lines?			*		
MAINTENANCE of certainty of machine downtime?				*	
to which maintenance represents a small 0% of production costs?				*	
of use of Total Productive Maintenance? (some maintenance tasks allocated to operators)				*	
of use of a Maintenance strategy to adapt to new equipment and/or model changes?		*			
TECHNOLOGY AND FLEXIBILITY to which can overcome bottlenecks/constraints?			*		

of sequencing flexibility - ability to alter order in which parts are fed into manufacturing process?					*
to which production technology is a competitive force?				*	
of implementation of Flexible Manufacturing System (FMS)?				*	
to which you can make new production technology work?				*	
of prioritisation of production of particular products?			*		
of disciplined shopfloor decision-making process?					*
of ability to manage expediting orders?					*
of ease of releasing orders?					*
to which production moves through standard sequence?					*
of use of despatch list?					*
of use of 'minute by minute' shopfloor control?					
of availability of highly accurate and timely information on the shopfloor?			*		
of use of computerised information system on the shopfloor?			*		
of visual inspection of work?		*			

CAPACITY ISSUES (TABLE 4)

Degree..........	Low				High
to which you can have a planned steady state capacity?				*	
to which you can balance shopfloor loading with customer demand e.g. shift human resources?					*
to which capacity can be expanded easily?					*
of ability to measure workload in terms of standard hours?					*
of use of time standards?					*
of availability of routing information?					*
of availability of efficiency and utilisation information allowing calculation of net 'rated' capacities?					*
of use of computerised Shopfloor Data Collection System?			*		
to which can change capacity by subcontracting/overtime?					*
to which capacity changes are fedback to Master Production Schedule?		*			
of usage of industrial engineers?					*

of use of finite capacity planning techniques?		*	
of use of infinite capacity planning techniques?		*	
of use of Rough Cut Capacity Planning (RCCP)?			*
to which plant working well below full capacity?	*		
of use of Capacity Requirements Planning System/Module (CRP)?	*		
of success with CRP?	*		
of use of spreadsheet packages for capacity planning?		*	

INVENTORY ISSUES (TABLE 5)

Degree..........	Low				High
INVENTORY DATA INTEGRITY of integrity of operations information - quality and quantity?					*
of monitoring and maintaining this data?					*
of strict discipline and validation at input stage?			*		
of on-time information retrieval and transmission?			*		
of real time data processing?		*			
of lengthy 'window' between when schedule is created and materials required at point of use?			*		
to which you identify reasons for changing schedules?				*	
of ease of coping with inventory activities - no. of transactions against a given sku per some time period?			*		
of correct assessment of inventory costs?				*	
to which access to the stockrooms is limited?			*		
of low value component items?			*		
of use of order quantity research?		*			

of existence of clear channel of communication between materials and accounts?	*			
to which Economic Batch Quantities (EBQ) uses correct estimates of input parameters to model?	*			
to which look at reasons for high stock levels?		*		
of usage of simplistic stocking policies?				*
to which these policies are periodically adjusted to reflect uncertainties?		*		
of use of tactical buffering of stock?			*	
to which pre-kitting is redundant?		*		
of use of cycle-counting?		*		
of use of ABC analysis (for inventory analysis)?		*		
of use of fixed location storage for stock?		*		
of organisation of stores?		*		
of use of electronic stores?	*			
to which internal customers are treated the same as external customers?	*			
to which inventory costs are falling?		*		
of use of information technology?			*	

of implementation of elements of JIT?			*	
to which computer based information system is utilised for MEP - Major Event Planning and medium-range planning?	*			
to which changes in receiving procedures have required development of alternate controls e.g. backflushing?		*		
of use of procedural integrity design?	*			
to which can cope with 100% material traceability?				*
to which working procedures are developed at the same rate as the firm is growing?			*	
of use of non-significant part numbers?	*			
MRP of use of where used lists/pegging?		*		
of use of medium-term 'what-if' simulations?	*			
of use of Materials Requirements Planning (MRP)?			*	
of use of net change MRP?		*		
of use of the outputs of MRP?		*		
of previous experience with MRP?		*		
of difficulty to do your job, if you didn't have MRP?			*	

of which you have more information to base decisions since MRP was introduced?	*			
to which you use feedback mechanisms of MRP?		*		
to which you have developed a production planning and control system in order to evaluate and regulate the effectiveness of each individual employee?		*		
SCHEDULING				
of availability of detail history on labour performance?				*
to which critical questions can be answered by your production planning and control system?	*			
to which you can cope with frequent schedule changes?			*	
are used on a shift-to-shift basis? to which detailed scheduling strategies?		*		
of use of cumulative lead time?	*			
of certainty surrounding the inputs to production planning and control system?	*			
of use of buffers				
- safety stock	*			
- safety lead time	*			
- safety capacity	*			
- forecast inflation	*			
- hedging and overplanning	*			
- yield factor			*	
of use of a hybrid production planning and control system (e.g. JIT and MRP)?				*

of suitability of current accounts system for the needs of manufacturing?		*	
MPS			
to which MPS is neither understated or overstated?		*	
of use of the following 5 major sources for changing MPS			
- production		*	
- shipments		*	
- performance changes		*	
- sales changes	*		
- engineering changes	*		
to which you have identified who should master schedule - requirements of person having being outlined?			*
of level of understanding of MPS?	*		
of use of procedures and responsibilities for creation of MPS?	*		
of appropriate planning horizons/time buckets/time fences in MPS?		*	
of procedures for dealing with backlogs and revisions in MPS?	*		
of analysis behind deciding what to master schedule?	*		
to which have an effective contingency planning system?		*	

WORKFORCE ISSUES (TABLE 6)

Degree..........	Low				High
CHANGE MANAGEMENT of status awareness of skilled workers?				*	
to which give workers have been given broader tasks?				*	
to which give workers planning tasks?				*	
to which implement group work?				*	
to which have capability to redesign manufacturing systems?				*	
to which flexible working is encouraged in all employees?					*
to which have disciplined approach to work?					*
to which operate in formal system?					
of managerial innovation and creativity?					*
of top management's willingness to delegate decision-making?				*	
of awareness that company operate in a very dynamic market, so employees are well aware of the need to continually improve the operations?					*
to which one person in charge of more than one function?				*	

of strategic approach to future recruitment of employees?					*
of need to think strategically about management of change?	*				
of top management commitment to implementation of production planning and control improvements (commitment with understanding)?	*				
of consensus management?			*		
to which shopfloor seen as source of ideas and constant improvement innovations?			*		
to which workers participate in Quality Circles?					*
to which resistance to change has been overcome?		*			
of accountability (competent personnel with clearly assigned responsibilities)?				*	
to which build accountability into people's jobs?					*
of labour motivation?			*		
EDUCATION AND TRAINING					

of education and training within the company?			*
of education and training in production planning and control?	*		
of consideration given to timing of education and training (education and training given in advance)?		*	
to which workers trained to perform a number of tasks e.g. maintenance			*
to which workers given a more comprehensive view of production process?		*	
to which workers participate in design/redesign of tasks?	*		
of supervisor training?			*
of direct personnel training?			*
of formal education and training programmes?			*
of learning curve improvements?			*
ORGANISATIONAL STRUCTURES of importance attached to job classifications?			*

of job security?		*		
of wage determination by teamwork and quality?		*		
to which can cope with personnel absenteeism?		*		
to which can cope with personnel turnover?		*		
of payment for wide range of skills?	*			
of indirect and direct labour productivity?			*	
to which communication channels open - management and unions?				*
of use of organisational integration techniques?			*	
of interdepartmental coordination?	*			
to which inventory ownership is focused?				*
of use of flat management structures?				*
good Industrial Relations?			*	

QUALITY ISSUES (TABLE 7)

Degree...........	Low	High

of certainty with regard to yield rates and 'right first time' production?			*
to which produce to quality standards?			*
of use of Statistical Process Control (SPC)?			*
of existence of ownership of quality (typified by development of operator certification)?			*
of use of supplier to inspect at source?			*
of use of special templates?			*
of use of process capability studies and verification?			*
of reduction in warranty and service costs?		*	
of use of poka yoke?			*
of use of Taguchi's loss function?			*
of use of waste reduction program?			*

SUPPLIER RELATIONS ISSUES (TABLE 8)

Degree..........	Low				High
SUPPLY STRATEGIES of accurate delivery status data available from suppliers?		*			
of formal JIT purchasing (management has established a plan or schedule in writing)?	*				
of purchase expenditures committed to multi-year contracts?		*			
of Supply Chain Management modeling?	*				
to which take impact of uncertainties in the supply chain into account?		*			

of identification of core competencies?			*	
to which these core competencies are manufactured in-house?			*	
of compatibility of company philosophies between you and your suppliers?		*		
of amount of sharing of risks and rewards with suppliers?	*			
to which try to understand threats and opportunities that suppliers face?	*			
of compatibility between suppliers' marketing and the company's supply strategies?		*		
to which exam underlying assumptions of present company-supplier coordination?		*		
SOURCING TECHNIQUES				

of use of supplier associations?		*			
of reduction in supply base?			*		
to which you dominate your suppliers?		*			
of use of parallel sourcing?	*				
of use of single sourcing?					*
of examination of suppliers' commercial, technical and managerial strengths when selecting suppliers?			*		
of analysis of process compatibility with suppliers?	*				
of early consultation with suppliers on design and delivery of products?		*			

of use of Design Approved (DA) suppliers (suppliers who will design components for you)?	*				
of use of Design Supplied (DS) suppliers (you supply the design for the supplier)?					*
of 'grey box' system purchases (grey box - you have an idea of the physical attributes and function of the item, but do not know the details)?		*			
of 'black box' system purchases (you can describe what is needed only from a functional standpoint)		*		*	
of use of common components in product design?			*		
to which follow industry standards in purchase of components?					
to which your suppliers have a multi-market presence?				*	
to which purchase prices are the consequence of decisions not the initiator?					*
to which recognise all costs associated with purchasing decisions?	*				
to which recognise some costs cannot be quantified?			*		
to which recognise cost premium for very frequent small deliveries?	*				
of use of price breaks?					

of use of specification characteristics when purchasing?				*	
of geographic closeness to suppliers?	*				
to which vehicles are suited for small JIT deliveries?			*		
to which suppliers have spare capacity?		*			
to which have compatible information systems with suppliers?	*				
of use of Electronic Data Interchange (EDI) with suppliers?			*		
to which can synchronise schedules with suppliers?			*		
of suppliers who have formal, disciplined systems?				*	
of bought-out parts?		*			
of use of blanket purchase orders?					*
to which size buffers appropriately for your supply chain?			*		
to which you adjust Finished Goods Inventory for your supply chain?		*			
to which logistical coordination replaces inventories in your supply chain?		*			

to which purchasing functions objectives are clear and non-conflicting?		*	
of understanding that in buying, you need people with input into what they are buying and what they are producing as well?	*		
of reliable supplier quality?		*	
of non-variation sources in supply?			*

CUSTOMER RELATIONS ISSUES (TABLE 9)

Degree..........	Low				High
to which you make accurate delivery status data available to your customers?					*
of which you can supply your customers JIT?					*
of multi-year contracts with customers?		*			
to which you are a first-tier supplier to customers?					*
of compatibility of company philosophies between you and your customers?					*
of amount of sharing of risks and rewards with customers?		*			
to which try to understand threats and opportunities that customers face?			*		
of compatibility between your marketing strategy and your customers' supply strategies?			*		
to which exam underlying assumptions of present company-customer coordination?			*		

to which you are the single source of supply for your customers?			*		
of examination your commercial, technical and managerial strengths by your customers?				*	
of analysis of process compatibility with customers?					*
of early consultation with customers on design and delivery of products?					
to which you are a Design Approved (DA) supplier to your customers (you design components for customer)?					*
to which you are a 'grey box' system supplier (grey box - you control the design detail of the system, but customers have an idea of the physical attributes and function of the item)?		*			
to which you are a 'black box' system supplier (you control the design of the system, customer can only describe what is needed only from a functional standpoint)?					*
of use of common components in product design by customers for your products?			*		
to which your customers follow industry standards in purchasing your components?			*		
to which your customers have a multi-market presence?				*	

to which selling prices are the consequence of decisions not the initiator?			*	
to which customers recognise a cost premium for very frequent small deliveries?	*			
of use of specification characteristics by customers when purchasing from you?				*
of geographic closeness to customers?	*			
to which have compatible information systems with customers?		*		
of use of Electronic Data Interchange (EDI) with customers?			*	
to which can synchronise schedules with customers?				*
of customers who have formal, disciplined systems?				*
to which you supply customers on a call-off basis?	*			
to which you supply reliable quality products to your customers?				*
of certainty of products accepted by customers?				*
of certainty of product attributes wanted by customers?				*
of certainty with regard to the amount of customer demand?			*	
to which build near customers?	*			

APPENDIX 10

CURRENT REALITY AUDIT DOCUMENT

COMPANIES C-J

CURRENT REALITY AUDIT DOCUMENT - COMPANIES C-J

STRATEGIC ISSUES (TABLE 1)

Degree..........	Low				High
PERFORMANCE MEASURES of use of performance measures?	E	F	C,H, I	J	D, G
to which you use a % improvement in each measure rather than absolute level?	E	C, F,H, I	D, G, J		
to which you use performance trends rather than absolute levels?	E	C, F,H, I	D, G, J		
to which you link Measures of Performance to Critical Success Factors (CSF)? (CSF - those factors which are critical for success in your industry)	E	F	C,H, I	D, J	G
to which you use the following Measures of Performance?					
days in inventory?	E	F	C, H, I	D, G, J	D,G
defective material?	E	F	C, H, I	J	G
on time delivery ?	E	C, F	H, I	D, J	G
past-due position?	E	C, F	H, I	D, J	G
% completion of Master Production Schedule (MPS)?	E, G	F	C, H, I	D, J	
lead time performance?	E	F	H, I	C,D, J	G
forecast accuracy?	E	C, F	H, I	G,D, J	
Bill of Material (BOM) accuracy?	E	C, F	H, I	D, J	G
inventory accuracy?	E	F	H, I	C,D, J	G

capacity utilisation?	E	C, F	H, I	D, J	
value-added and non-value added costs?	E	F	C, H, I	G, D, J	
part standardisation?	E	C, F	G, H, I	D, J	
cost of quality?	E	C, F	H, I	G, J	D
set-up and changeover time?	E	F	C, H, I	D, J	G
machine reliability?	E	F	C, H, I	D, J	G
employee suggestions?	E	F	C, H, I	D, J	D, G
to which you question the appropriateness of your current measures of performance?	E	C	F, H, I	J	D,G
BENCHMARKING to which you use benchmarking?	C, E		D, F, H	I, J	G
to which you benchmark your products against the competition?	C, E		D, F	H, I, J	G
to which you benchmark your processes?	C, E		D,F, H, I, J		G
to which you benchmark internally?	C, E	D		G, H, I, J	
to which you benchmark against the competition?	C, E	D	F, H	I, J	G
to which you benchmark against the best-in-class? (could be in a completely different industry but best at a particular process e.g. new product introduction)	C, E	D	G, F, H, J	I	
to which you carry out strategic benchmarking? (integrates strategic competitive analysis	C, E	D	G, F, H, I, J		

with best-in-class)					
COST CONTROL to which budgetary control system focuses on long-term targets?		C, E	F, I, J	D, G, H	
to which you use activity-based costing?		C, E, F, J	D, H, I	G	
to which you use process costing?		E, F	C,D, H, I, J		G
MANUFACTURING STRATEGY of use of a clear manufacturing /operations strategy?		F	C, E, I	D, H	G, J
to which your industry is stable in nature?		C, D, H	G, D.F, I, J		
to which you compete on the basis of your quality exceeds all industry standards?			E, F, H, I, J		C, D,G
to which you compete on the basis that your products are unique?	E	J	F, H, I	C, G	D
to which you compete on the basis of having an extraordinary design capability?	E	J	F, H, I	C	D
to which you compete in a non-standard product environment?	E	J	F, H, I		C,D, G
to which your customers have certain demand?	H, I, J	C, E	F	D	G
to which your customers' dominant competitive pressure is low cost?		D, E, F	C,H, I	J	G
to which your customers' dominant competitive pressure is delivery performance?		G	C, D, F, J	E,H, I	

of value-adding capability within your plant?		E	H, I, J	C, F	D,G
to which you follow the focused factory concept?		E, F	I	C, D, H, J	G
to which you make-to-order (MTO) and/or assembie-to-order (ATO)?	J		C, E, F	D, H	G, I
to which you ask the following questions?					
how do customers see us?		E	D, F	C, H, I, J	G
what must we excel at?		E	C, D, F	H, I, J	G
can we continue to improve and create value (innovation and learning perspective)?		E	C, D, F	H, I, J	G
how do we look to shareholders (financial perspective)?		C, E, F	D	G, H, I, J	

PRODUCT ISSUES (TABLE 2)

Degree..........	Low				High
DEMAND DATA					
of sales forecast accuracy?	H, I	C. E, F, J	G	D	
to which you have a regular demand pattern?	H, I,	E, F, J	C, G	D	
of certainty as to the length of product life cycles?		E, F, H, I	G, J	C	D
to which can cope with revisions of customer demand?		E,F, H, I, J	C	D	G
DESIGN					
to which you design with Supply Chain Management considerations in mind?		E, F, J	C, D, I	G, H	
of use of concurrent engineering (simultaneous engineering)?		E, F, J	C, D, H, I	G	
of use of Design for Manufacture (DFM) and Design for Assembly (DFA)?		E, F	C, D, H, I	G, J	
of use of Computer-Aided Design (CAD)?			E, F, H, I, J	C	D, G
of use of modularised product designs?		E, G	C, F, J	D, H, I	
of use of planning bill of materials?	H	E, F, I, J	C, D, G		
of simplicity of your bill of materials?	D	C, F, H	G	E,	I, J
- breadth - (defined by no. of immediate components per parent in BOM)		C, F, H	D, G	E	I, J
- depth - no. of levels in BOM	D	C, F, H	G	E	I, J

to which you design new products on time?		C, F	D, E, H	G, I, J	
to which you introduce new products on schedule?		C, F	D, E, H	G, I, J	
of engineering changes?	D, H	C	G, E, F, I, J		
to which effectivity dates adhered to?	D, H		C, E, F, I, J	G	
to which the lead time(LT) accepted by customers is greater than the LT of your manufacturing system?.		C, F	D, E, H, I, J	G	
to which LT quoted by marketing to obtain customer orders is less than manufacturing lead time?		F, H	C, D, E, I, J	G	
of simplicity in number of variants per product?		D,G, F, I, J	E, H	C,	
of runners and repeaters? (runners defined products regularly ordered - repeaters defined as products occasionally ordered)		C, D, I	G, E	F, H, J	
of ease of introducing new products?		C, D	G, F, I	H, J	E
of product family categorisation?			F, I	D, E, H, J	C,G
to which you don't have to support and maintain products in the long-term?		C	F, H, I	G, E, J	D
MPS					

to which you use a Master Production Schedule?	F, H	C,E, G,I, J	D		
to which you develop the demand side of the MPS - (e.g. Available to Promise ATP/forecasting/planning bills)?	F, H	C, E, I, J	D		G
to which you develop the supply side deficiencies of the MPS - checking validity of plans and schedules in terms of available capacity?	F, H	C, E, I, J	D	G	

PROCESS ISSUES (TABLE 3)

Degree..........	Low				High
LEAD TIMES					
to which have short process lead times?	C	D, F	H, I, J	E	G
to which you operate a LT reduction program?		E, F	D, H, I, J	C	G
of reliability of lead times?	C, D, I	E, F	H, J		G
of which you deliver on time?	C,	F	D,E,J	H, I	G
PRODUCTION FLOW					
to which products flow through the shopfloor without the need to queue?	C	F	D, E, J	H, I	G
to which process facilities are designed for reliability and ease of maintenance?			C, F	D, E, H, I, J	G
to which you use task forces/project teams etc.for process redesign purposes.		E	C, F	D, H, I, J	G
to which you develop new processes for old products?		E	D, F, I, J	C, H	G
of volume production?		C, D		G, F	E, H, I, J
to which you have few manufacturing operations?		D,F, H	C, I, J	E	G
to which you have few shopfloor routings?	C	F, H	D, I, J	G, E	
to which you have a low number of works orders?		C, F, H	G. D, I, J	E	
to which you operate in a static/slow moving environment?		C, D, E, H, I	F	J	G

to which you use alternative routings and processes?		C, D, I	F, H, J	G	E
of potential production mix alternatives available to you?		C, D, I	F, H, J		G, E
of repetitiveness of operations?		D	C, F	I, J	G,H, E
to which you try and reduce set-up times?		F	C, D, H, I	E, J	G
of use of a continuous improvement program?		E	C, F, H, I	D, J	G
of your awareness of Theory of Constraints (TOC)?		C, E, F, H, I, J	G, D		
of standardisation of operations?		C, F	D	E, H, I, J	G
CELLS of use of cellular manufacturing?			D, E, F	C, H, I	G, J
to which shopfloor control is decentralised?			D, E, F	C, H, I	G, J
of local performance measures being linked to global business measures?	E	F	C	H, I	D, G, J
of use of performance measures for cellular manufacturing?	E	F	C	H, I	D, G, J
of use of Group Technology?			D,E, F	H, I	C, G, J
of space savings resulting from cellular manufacturing?			D, E, F, H	C, I	G
of use of physical cells?			D, E, F	H, I	C.G, J
of use of logical cells?			D, E, H, I	C	G, J

to which system allows cells to grow and shrink as demand dictated with associated movement of workers across boundaries?			D, E, F, I	C, H	G, J
of ease of selecting cell workers?			C, D, E, F	H, I	G, J
of ease of justifying cellular manufacturing?		D	E, F	C, H, I	G, J
to which cellular manufacture has a structured interface to rest of organisation?			D, E, F	C, H, I	G, J
of use of standard containers on the shopfloor for material movement?		D, F	C, E	H, I	G, J
of use of kanbans?		C, D, E, F	H, I	J	G
of use of dedicated Just-inTime (JIT) production lines?		C, D, E, F	I	G, H	J
MAINTENANCE of certainty of machine downtime?		E	C, D, F, H, I, J		G
to which maintenance represents a small 0% of production costs?		C, D, J	F, H, I,	E	G
of use of Total Productive Maintenance? (some maintenance tasks allocated to operators)		C, E, F	H, I, J	D	G
of use of a Maintenance strategy to adapt to new equipment and/or model changes?		C, E, F	H, I, J	G, D	
TECHNOLOGY AND FLEXIBILITY to which can overcome bottlenecks/constraints?	F, J	D	C, H, I	E	G

of sequencing flexibility - ability to alter order in which parts are fed into manufacturing process?	C, D, H, I, J	F,	E	G
to which production technology is a competitive force?	I	E, H	F, J	C, D, G
of implementation of Flexible Manufacturing System (FMS)?	F, I	C, D, E, H	J	G
to which you can make new production technology work?		F, H, I	E, J	C, D G
of prioritisation of production of particular products?		C, F, H, I	D, E, J	G
of disciplined shopfloor decision-making process?		C, E, F, H, I	D, J	G
of ability to manage expediting orders?		C, D, E, F, H, I	J	G
of ease of releasing orders?	C, D	F, H, I	E, J	G
to which production moves through standard sequence?	F	E	C, D, H, I, J	G
of use of despatch list?		C, D, H, J	E, F, I	G
of use of 'minute by minute' shopfloor control?	C, D	E, F, H	I, J	G
of availability of highly accurate and timely information on the shopfloor?	C, E, F	D, H, I	J	G
of use of computerised information system on the shopfloor?	D, E, F	H, I	C, J	G
of visual inspection of work?		E, F	C, D, H, I, J	G

CAPACITY ISSUES (TABLE 4)

Degree..........	Low				High
to which you can have a planned steady state capacity?	H, I	E, J	C, D		G
to which you can balance shopfloor loading with customer demand e.g. shift human resources?	H, I	E, F, J	C, D		G
to which capacity can be expanded easily?		C, D, E, F, H, I	G, J		
of ability to measure workload in terms of standard hours?	E	C, F,I	D, H	J	G
of use of time standards?	E	C, F,I	D, G, H	J	
of availability of routing information?	E	F, I	D, H	C,G, J	
of availability of efficiency and utilisation information allowing calculation of net 'rated' capacities?	E	F, I	C, D, H	G, J	
of use of computerised Shopfloor Data Collection System?		C, D, E,F, G, H, I		J	
to which can change capacity by subcontracting/overtime?		C, D, H	I	E, F,G, J	
to which capacity changes are fedback to Master Production Schedule?	F, H	C, E, J	I	D	G
of usage of industrial engineers?		C, E	D, F, H, I, J	G	

of use of finite capacity planning techniques?	E, F, I	C, G, H, J	D	
of use of infinite capacity planning techniques?	E, F, I	C, G, H, J	D	
of use of Rough Cut Capacity Planning (RCCP)?		C, E, F, G, H, I, J		D
to which plant working well below full capacity?	G, H	F, I, J	C, D, E	
of use of Capacity Requirements Planning System/Module (CRP)?	C, D, E, F, G, H, I, J			
of success with CRP?	C, D, E, F, G, H, I, J			
of use of spreadsheet packages for capacity planning?	E	C, D, H, I, J	G, F	

INVENTORY ISSUES (TABLE 5)

Degree.........	Low				High
INVENTORY DATA INTEGRITY of integrity of operations information - quality and quantity?	C, F	C, E, H, I	D, J		G
of monitoring and maintaining this data?	H, J	E. F, I	D		G
of strict discipline and validation at input stage?		C, E, F, H, I	D, J	G	
of on-time information retrieval and transmission?	E	C, F, I	D, H	G, J	
of real time data processing?	E	C, F, I	G, D, H	J	
of lengthy 'window' between when schedule is created and materials required at point of use?	E,	F, H, I	C, G, J	D	
to which you identify reasons for changing schedules?		C, E, F, H, I	D, J		G
of ease of coping with inventory activities - no. of transactions against a given sku per some time period?	J	C, E,F, H , I	D		G
of correct assessment of inventory costs?	C, F	E, I	D, H, J		G
to which access to the stockrooms is limited?	G	C, E, F	H, I, J		D
of low value component items?	C, D	G, F	H	I, J	E
of use of order quantity research?	G	C, D, E, F, H, I, J			

of existence of clear channel of communication between materials and accounts?		C, H	G, F, J	D, E, I	
to which Economic Batch Quantities (EBQ) uses correct estimates of input parameters to model?	G	C, D, E, F, H, I, J			
to which look at reasons for high stock levels?		C, E, F	H,I, J		D,G
of usage of simplistic stocking policies?		C, D, F	H, J	E, I	G
to which these policies are periodically adjusted to reflect uncertainties?		C, E, F	D, H, J	I	G
of use of tactical buffering of stock?		E, F	C, D, G, H, J		I
to which pre-kitting is redundant?		C, E	D, F, H, I, J		G
of use of cycle-counting?	F	D,E	H, I, J	C	G
of use of ABC analysis (for inventory analysis)?		E, F	C, D, H, I, J		G
of use of fixed location storage for stock?		E,F	H, J	C, D, G, I	
of organisation of stores?			C, E, F, H, J	D, G, I	
of use of electronic stores?			C, E, F, H.	I, J	D, G
to which internal customers are treated the same as external customers?		F	D, E, H, J	C, I	G
to which inventory costs are falling?		C, F	D, E, H, J	G, I	
of use of information technology?			C, E, F.	D, H, I, J	G

of implementation of elements of JIT?		C, E	D, F, I	H, J	G
to which computer based information system is utilised for MEP - Major Event Planning and medium-range planning?		E	C,D, F, G, H, I, J		
to which changes in receiving procedures have required development of alternate controls e.g. backflushing?	C	E, F	H, I, J	D	G
of use of procedural integrity design?	C, G	E, F, I	H,	J	D
to which can cope with 100% material traceability?	D	E, F	C, G	H, I,	J
to which working procedures are developed at the same rate as the firm is growing?	C	E, F	H	D, I, J	G
of use of non-significant part numbers?	G, J	C, D, E, F, H, I			
MRP					
of use of where used lists/pegging?	C, E	D, F, I, J	G, H		
of use of medium-term 'what-if' simulations?	G, E	C, F, I, J	D, H		
of use of Materials Requirements Planning (MRP)?	C, E	F, I, J	D, H		G
of use of net change MRP?	C, E	F, I, J	D, H		G
of use of the outputs of MRP?	C, E	F, I, J	D, H		G
of previous experience with MRP?		C, E, J	D, F, I	H	G
of difficulty to do your job, if you didn't have MRP?			C, D, E, F,I, J	H	G

of which you have more information to base decisions since MRP was introduced?		C, E, I, J	D, H	F	G
to which you use feedback mechanisms of MRP?	C, E	F, I, J	D, H		G
to which you have developed a production planning and control system in order to evaluate and regulate the effectiveness of each individual employee?	E	C, F,	D, G, H		J
SCHEDULING of availability of detail history on labour performance?	E, G, I	C, F,	D, H		J
to which critical questions can be answered by your production planning and control system?	E, F, I	H	C, D	J	G
to which you can cope with frequent schedule changes?	F, H	C, E, I	D, J		G
are used on a shift-to-shift basis? to which detailed scheduling strategies?		E, F, H	C, I	D, J	G
of use of cumulative lead time?		C, E	D, F, H, I, J		G
of certainty surrounding the inputs to production planning and control system?	H, I	C, E, F, J		D	G
of use of buffers					
- safety stock		C, F, H, J	E,D, G		I
- safety lead time		F, H, J	E, D,G	C, I	
- safety capacity		C, F, H, J	E,D, G	I	
- forecast inflation		C, F, H, J	E, D,G	I	
- hedging and overplanning		C,D, F, G,			
- yield factor		E, H, I, J	D,E	C, G	
		F, H, I, J			
of use of a hybrid production planning and control system (e.g. JIT and MRP)?	G	C, E, I	D, F, J		H

of suitability of current accounts system for the needs of manufacturing?		C	D,E,G, H, I, J	F	
MPS					
to which MPS is neither understated or overstated?	F,G, H, I	E	C, D, J		
of use of the following 5 major sources for changing MPS					
- production	E, F, I	J	D, H	C, G	
- shipments	E, F, I	J	C, D, H		G
- performance changes	E, F, I	J	D, H	C, G	
- sales changes	E, F, I	J	C, D, H		G
- engineering changes	E, F, I	J	H	C,D, G	
to which you have identified who should master schedule - requirements of person having being outlined?	F	E, I, J	D, G, H	C	
of level of understanding of MPS?		E, F, I, J	G, H	C, D	
of use of procedures and responsibilities for creation of MPS?	E, F	C, I, J	D, G, H		
of appropriate planning horizons/time buckets/time fences in MPS?	E, F	H, I, J	D, G	C	
of procedures for dealing with backlogs and revisions in MPS?	E,F, I	H, J	D, G	C	
of analysis behind deciding what to master schedule?	E, F	H, I, J	D. G	C	
to which have an effective contingency planning system?		E, F, J	H, I	C,D, G	

WORKFORCE ISSUES (TABLE 6)

Degree.........	Low				High
CHANGE MANAGEMENT					

of status awareness of skilled workers?			E, H, I, J	D	C,F,G
to which give workers have been given broader tasks?			E, H, I, J	D, F	C, G
to which give workers planning tasks?		E	H, J	C, D, F, I	G
to which implement group work?		E		D, F, H, I	C, G, J
to which have capability to redesign manufacturing systems?		E	F, I	C,D, G, H, J	
to which flexible working is encouraged in all employees?			E	F, H, I, J	C,D, G
to which have disciplined approach to work?		E	C, F. I	G, H, J	D
to which operate in formal system?	C, E	G,	F, I	D, H, J	
of managerial innovation and creativity?			C, E	D, F, H, I, J	G
of top management's willingness to delegate decision-making?		C, D	E, F, H	I, J	G
of awareness that company operate in a very dynamic market, so employees are well aware of the need to continually improve the operations?			C, F, I, J	D, E	G, H
to which one person in charge of more than one function?			D, F, H, J	C, I	E,G
of strategic approach to future recruitment of employees?		E	C, F, J	D, H, I	G
of need to think strategically about management of change?	D	E	C, F	H, I, J	G

of top management commitment to implementation of production planning and control improvements (commitment with understanding)?	C, I	E	D, F, H, J	G
of consensus management?	E	C, D, F, H, J	I	G
to which shopfloor seen as source of ideas and constant improvement innovations?	E	H, I, J	C,D, F	G
to which workers participate in Quality Circles?	E	C, H,I, J	D, F	G
to which resistance to change has been overcome?		D, E, H	C, F, I, J	G
of accountability (competent personnel with clearly assigned responsibilities)?		C, E, F	D, H, I, J	G
to which build accountability into people's jobs?		C, E, F	D, H, I, J	G
of labour motivation?		D, E, F	C, H, I, J	G
EDUCATION AND TRAINING				

of education and training within the company?	C, D, E	F	I, J	H,	G
of education and training in production planning and control?	C, D, E, F, I		J	H	G
of consideration given to timing of education and training (education and training given in advance)?	C, D, E	F, I	J	H	G
to which workers trained to perform a number of tasks e.g. maintenance		E, F	C, J	D, H, I	G
to which workers given a more comprehensive view of production process?	E	F	C, J	D, H, I	G
to which workers participate in design/redesign of tasks?	E	F	C, J	D, H, I	G
of supervisor training?	E	D, F	C, J	H, I	G
of direct personnel training?	E	D, F	C, J	H, I	G
of formal education and training programmes?	C, D, E	F	I, J	H	G
of learning curve improvements?	E, F		C, J	D, H, I	G
ORGANISATIONAL STRUCTURES of importance attached to job classifications?		C, D, E	F, H, J	I	G

of job security?		E	C,D,F, G, H, I,J		
of wage determination by teamwork and quality?		E	D, F	C, G, H, I, J	
to which can cope with personnel absenteeism?		C, E	D, F, I, J		G
to which can cope with personnel turnover?		C, D, F	E, H , J	I	G
of payment for wide range of skills?		E,	F, H, J	C,D, G, I	
of indirect and direct labour productivity?			C, D, E, F	G, H, I, J	
to which communication channels open - management and unions?		J	E, F	C, D, H, I	G
of use of organisational integration techniques?	H	C	E,F, J	D, I	G
of interdepartmental coordination?	H	C	E, F, J	D, I	G
to which inventory ownership is focused?			C, E, F,H, J	D, I	G
of use of flat management structures?			F, H, J	D, I	C, E, G
good Industrial Relations?		J		D, E, H, I	C, G

QUALITY ISSUES (TABLE 7)

Degree...........	Low				High
of certainty with regard to yield rates and 'right first time' production?		C	F	D, E, H, I, J	G
		C	F	E, H, I	D,G, J
to which produce to quality standards?					
		C	D, E.F, G	H, I, J	
of use of Statistical Process Control (SPC)?					G
		C	D, E, F	H, I, J	
of existence of ownership of quality (typified by development of operator certification)?		C, E	D,	H, I, J	G
			C,D , E, F, H, I	J	G
of use of supplier to inspect at source?			C, D, E, F, H	I, J	G
of use of special templates?				I, J	G
of use of process capability studies and verification?	G	C, E, F	C, D, E, F, H		
of reduction in warranty and service costs?	G	C, E, F	D, H, I, J		
		C, E		G, I, J	
of use of poka yoke?			D, H, I, J		
of use of Taguchi's loss function?			D, F, H		
of use of waste reduction program?					

SUPPLIER RELATIONS ISSUES (TABLE 8)

Degree..........	Low				High
SUPPLY STRATEGIES					
of accurate delivery status data available from suppliers?	D, F, I	C, E,	H, J		G
of formal JIT purchasing (management has established a plan or schedule in writing)?	F, I	C, D, E	G, J	H	
of purchase expenditures committed to multi-year contracts?		C, E, F	D, I	H, J	G
of Supply Chain Management modeling?		C, E, F, J	G, I	D, H	
to which take impact of uncertainties in the supply chain into account?		E, F, J	C, G, I	D, H	

of identification of core competencies?			E, F, H, I, J	C, G	D
to which these core competencies are manufactured in-house?			E, F, H, I, J		C,D, G
of compatibility of company philosophies between you and your suppliers?	D	E,J	C, F, G, H, I		
of amount of sharing of risks and rewards with suppliers?	D	E, F, J	C, G, H, I		
to which try to understand threats and opportunities that suppliers face?	D	E, F, J	C, H, I	G	
of compatibility between suppliers' marketing and the company's supply strategies?	D	E, F,J	C,G, H, I		
to which exam underlying assumptions of present company-supplier coordination?	D	E, F, J	G, H, I	C	
SOURCING TECHNIQUES					

of use of supplier associations?	D	C, E, F, H, I, J	G		
of reduction in supply base?	C, D, F, H, I	E, J			G
to which you dominate your suppliers?		C, E, F, I, J		G	H
of use of parallel sourcing?	F	C, E, H, I, J	G	G	
of use of single sourcing?	F	C, E, H, J		I	
of examination of suppliers' commercial, technical and managerial strengths when selecting suppliers?	D, F	C, E, H, I, J		C	G
of analysis of process compatibility with suppliers?	D, F	E, H, I, J			G
of early consultation with suppliers on design and delivery of products?	D, F	C, E, H, I, J			G

of use of Design Approved (DA) suppliers (suppliers who will design components for you)?	G, F	C, E,H, J	D	I	
of use of Design Supplied (DS) suppliers (you supply the design for the supplier)?	F	C, E, J	D	H, I	G
of 'grey box' system purchases (grey box - you have an idea of the physical attributes and function of the item, but do not know the details)?	G, F	C, E, H, I, J	D		
of 'black box' system purchases (you can describe what is needed only from a functional standpoint)	G, F	C, E, H, I, J	D		
of use of common components in product design?		C, D,F	E, G	H, I, J	
to which follow industry standards in purchase of components?		C, D, F	E	H, I, J	G
to which your suppliers have a multi-market presence?		C, D, E, H	G, F, I, J		
to which purchase prices are the consequence of decisions not the initiator?		C	D, E, F, H, I, J	G	
to which recognise all costs associated with purchasing decisions?		C	D. E. F. H. I, J	G	
to which recognise some costs cannot be quantified?		C	D. E. F. H. I, J	G	
to which recognise cost premium for very frequent small deliveries?		C		G	
of use of price breaks?		C	D, E. F. H. I, J	J	

of use of specification characteristics when purchasing?			E, F, H, I	J	C,D, G
of geographic closeness to suppliers?	D,I	G		C, E, F, H, J	
to which vehicles are suited for small JIT deliveries?			C, D,E,F,G, H, I, J		
to which suppliers have spare capacity?	D	C,F, I	E, H, J	G	
to which have compatible information systems with suppliers?		C,D, E, F, H, J	G, I		
of use of Electronic Data Interchange (EDI) with suppliers?		C, D, E, F,G, H, J	I I	G, H	
to which can synchronise schedules with suppliers?		C, D, E, F, J	D, I	H, J	
of suppliers who have formal, disciplined systems?		C, E, F,			G
of bought-out parts?			G, D, E, F, I, J	C	H
of use of blanket purchase orders?		F	C, E, D,G, I	H, J	
to which size buffers appropriately for your supply chain?			C, D, E, F	G, H, J	I
to which you adjust Finished Goods Inventory for your supply chain?			C, D. E, F, H	I, J	G
to which logistical coordination replaces inventories in your supply chain?	I		C, D, E, F, J	H,	G

to which purchasing functions objectives are clear and non-conflicting?		C, D, E, F, J	G, H, I	
of understanding that in buying, you need people with input into what they are buying and what they are producing as well?		C, D, E, F, J	G, H, I	
of reliable supplier quality?	F	C,E, D, I	H, J	G
of non-variation sources in supply?	F	C, E, D, I	H, J	G

CUSTOMER RELATIONS ISSUES (TABLE 9)

Degree...........	Low				High
to which you make accurate delivery status data available to your customers?	F	C, E, H, I	D	J	G
of which you can supply your customers JIT?		C, E, F, I	D	J	G, H
of multi-year contracts with customers?		D, E, F, I	C,	G, H, J	
to which you are a first-tier supplier to customers?		E	I,J	C, F	D, G, H
of compatibility of company philosophies between you and your customers?	G	E	C, F, H, I, J	D	
of amount of sharing of risks and rewards with customers?		E	C,F , H, I, J	D	G
to which try to understand threats and opportunities that customers face?		E	C, F, H, I, J	D	G
of compatibility between your marketing strategy and your customers' supply strategies?		E	C, F, G, H, I, J	D	
to which exam underlying assumptions of present company-customer coordination?		E	C, F, H, I, J	D	G

to which you are the single source of supply for your customers?	E, I, J	F, G, H	C, D	
of examination your commercial, technical and managerial strengths by your customers?	E, I, J	F, H	C, D	G
of analysis of process compatibility with customers?	E, H, I, J	F,	C, D	G
of early consultation with customers on design and delivery of products?	C, E, I	D, F, H	J	G
to which you are a Design Approved (DA) supplier to your customers (you design components for customer)?		E, I	C, D, F, H, J	G
to which you are a 'grey box' system supplier (grey box - you control the design detail of the system, but customers have an idea of the physical attributes and function of the item)?	E, H, I, J	F	C, D, G	
to which you are a 'black box' system supplier (you control the design of the system, customer can only describe what is needed only from a functional standpoint)?	E, H, I, J	C, F	C, D, G	
of use of common components in product design by customers for your products?	C, D	E, F	H, I	G, J
to which your customers follow industry standards in purchasing your components?	C, D	E, F	H, I	G, J
to which your customers have a multi-market presence?		E	C, F, H, I, J	D, G

to which selling prices are the consequence of decisions not the initiator?			C,D, E,F, G, H, I, J		
to which customers recognise a cost premium for very frequent small deliveries?		C	D, E, F, H, I, J	G	
of use of specification characteristics by customers when purchasing from you?			H, I,	E, J	C,D,F ,G
of geographic closeness to customers?	G	C, F, I, J	D, H		E
to which have compatible information systems with customers?	G	E, F, J	C, H, I	D,	
of use of Electronic Data Interchange (EDI) with customers?	G	C, E, F, J	D, H, I		
to which can synchronise schedules with customers?	H	C, E, F, J	D, I		G
of customers who have formal, disciplined systems?		E,	I	F, H, J	C,D, G
to which you supply customers on a call-off basis?		C, D, F	H, I	E, J	G
to which you supply reliable quality products to your customers?				E, F, I	C,D G, H,
of certainty of products accepted by customers?		H, I	C, F, J	D, E	G
of certainty of product attributes wanted by customers?			C, E. F, H, J	D, I	G
of certainty with regard to the amount of customer demand?	H, I	J	E	C, F	D, G
to which build near customers?		C, F, G, I, J	H	D	E