REVISING THE PARADIGM OF CONTROL IN REPETITVE PRODUCTION

by

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SUMMARY

This thesis is based on seven case studies from a wide range of industries. It challenges the traditional paradigm of control in production management practice and literature, proposing a revised paradigm bringing together the control and improvement processes and integrating them with corporate competitive strategy.

The traditional paradigm leads to two possible states; 'in' and 'out of' control'. Which state is attained is dependent on the balance between the difficulty of the manufacturing task and production management's competence to exercise control; when the difficulty is greater than the competence production becomes 'out of control'.

In the traditional paradigm production management seeks to maintain stability. The research shows that competition frequently leads to increases in the difficulty of the manufacturing task, which disturb this stability. I show that senior management does not adequately recognize the consequences of this difficulty on the state of control.

The fieldwork demonstrates that production managers exercised control in terms of compliance to standards, with improvements being left to staff specialists, who tended to concentrate on new systems, or major revisions to existing practices. Neither group gave significant priority to making small incremental changes to the existing technology / systems.

A revised paradigm is developed showing that control of production can be maintained in line with competitive pressures, by involving production management and workers in the improvement of the manufacturing system. At its best production then becomes a source of competitive advantage. The improvements are achieved via a programme of strategically directed continuous incremental changes executed on the shop floor. They come from analysis of 'shop floor' information used to reduce the complexity and uncertainty of the manufacturing task. These improvements complement the 'discrete' system changes accomplished by functional staff. The paradigm requires high levels of learning and problem solving skills by production management and workers.

Three elements are identified within the revised paradigm which affect a company's rate of improvement; the existence of clear strategies for manufacturing, a coherent formal improvement plan and the provision of information to monitor and analyse improvements and control.

CONTENTS

	Page
Contents	i
Acknowledgements	ii
List of Figures	iii
List of Tables	v
List of Abbreviations	vii
1. Introduction	1
2. Review of the Literature	3
3. Method of Study	37
4. The 'In Control' Condition of the Traditional Paradigm of Control in Production	46
5. The 'Out of Control' Condition of the Traditional Paradigm of Control in Production	107
6. The 'Continuous Incremental Improvement and Control' Paradigm	158
7. Conclusions	211
APPENDICES	
A. Detailed Method of Study	222
B. Illustrative Sets of Control and Improvement Reports	265
Bibliography	280

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LIST OF FIGURES

1	The Framework of the Paradigms for the Control of Production	41
2	The Traditional Paradigm of Control in Production	47
3	An Illustration of the Comparison between 'Stable' Production Performance and Adaptive Market Requirements	49
4	The Managing Director of the Clutch Case's Expectation of Contributions to Competitiveness from all Plant Functions	60
5	A Comparison of the Managing Director's Ratings of Departmental Contributions to Competitiveness and their Key Tasks	62
6	Reporting Scheduled Range of Products per Month in the Pump Case	70
7	Issues Inadequately considered by Senior Management in the Traditional Paradigm	82
8	The Relationship between the Complexity of the Manufacturing Task and the Competence of the Production Managers	83
9	The Relationship between the Various Sources of Information used by Production Managers	85
10	Qualifications of Managers / Supervisors ('In Control' Cases)	103
11	The Managing Director's Expectation of Contributions to Current and Future Competitiveness from the Individual Departments (Brake Case)	120
12	Cumulative Sums of Departmental Performance Report Values (Brake Case)	128
13	Number of Reports in Four Week Period by Manufacturing Manager (Brake Case); Compared with Average of the 'In Control' Cases	137
14	Degree of Month End Output Storming in O.E. and Service Parts in the Brake Case Study	149
15	Part of the Framework of the Paradigm of the Control of Production ('continuous incremental improvement & control' condition)	159
16	Classification of Characteristics of Plants	162
17	A Schematic View of the Revised Paradigm	165
18	An Illustration of the Relationship between Uncertainty, Complexity & Competence with the State of Control	177

19	A Comparison of the Traditional and Revised Control Cycles	182
20	Reporting Labour Performance in the Food Processing Case	206
21	The Classification of Reports by Topic and Frequency	228
22	The CLIP System Applied to the Production	269
23	The Cost of Quality	272
24	Summary of Internal Quality Data Affecting Uncertainty	273
25	Rejection of 'First-offs' and 'Process Stops' by Patrol Inspection (from Brake Case)	273
26	A Corporate Measure of Flexibility	276
27	Monitoring Improvements in Changeover Times	277

LIST OF TABLES

1	A Summary of the States of Control in the Case Studies	42
2	Estimated Changes in Monthly Demand for Top and Bottom 10 Types of Clutch in the Product Ranges	53
3	Rank Order Comparison of Factors Affecting Sales	54
4	The Main Forms of 'Stepped Change' in the 'Steady State' Cases	56
5	The Proportion of the Reports Received by Managing Directors on the Major Categories of Performance	73
6	A Comparison of KMTs and Information Received by the Managing Director of the Clutch Case	75
7	Production Management's Preferred Sources of Information	85
8	Comparison of Time to Obtain Information: Direct v. Formal Systems (Pump Case)	87
9	The Proportion of Routine Control Reports Received by the Production Managers on the Major Categories of Performance	89
10	The Quality of Fit between Reports Received by Production Managers and their Plant's KMTs	91
11	Increasing the Requirements Affecting the Difficulty of the Manufacturing Task	111
12	A Comparison of KMTs and the Managing Director's Control Information (Brake Case)	114
13	Ratio of Production Directs to Total Employees ('Out of Control' Cases)	121
14	Volume of Transactions in a Two Year Period (Kitchen Case)	122
15	Comparison of KMTs and Weaknesses of Written Information (Brake Case)	134
16	Ranking of Managers' Preferred Sources of Information	135
17	Differences in the Pattern of Preferred Sources	136
18	The Quality of Fit between Reports Received by Production Managers and their Plant's KMTs/OWC	138

19	A Comparison of Customer Service & Resource Efficiency in 'Out of Control' & 'In Control' Case Studies	141
20	Comparison of Time to Obtain Information: Direct v. Formal Systems (Brake Case)	147
21	Analysis of the Inspection Records of a Department (Brake Case)	153
22	A Comparison of the First Run Capability of Paintshops	174
23	Competitive Priorities over the Next Two Years (in a sample of 239 U.K. manufacturing plants)	176
24	Comparing the Percentages by Topic in the 'In Control' Cases and Food Processing Case	191
25	A Comparison of Order Winning and Qualifying Criteria and the Managing Director's Control Information	192
26	Production Managements' Preferred Sources of Information	198
27	Issues Identified as Important for Improvement by the Production Manager and / or Supervisors in the Food Processing Case	203
28	Example of Delivery Performance Analysis	268
29	Size of Orders and Delivery Performance	268

LIST OF ABBREVIATIONS

EOQ	Economic Order Quantity
FMS	Flexible Manufacturing Systems
JIT	Just in Time
KMTs	Key Manufacturing Tasks
MIS	Management Information System
MRP(II)	Materials Requirements Planning
OE	Original Equipment
OQC	Order Qualifying Criteria
OWC	Order Winning Criteria
PIMS	Profit: Impact of Market Strategy
PMT	Predetermined Motion Time (systems)
POM	Production Operations Management
PPC	Production Planning & Control
SPC	Statistical Process Control
SQA	Supplier Quality Assurance
TQC	Total Quality Control
WIP	Work in Progress

1. INTRODUCTION

Two major influences stimulated this research. Firstly, my experience working in industry and later as a management trainer. Secondly, mounting evidence of relatively poor performance by a number of British (and American) manufacturers, which led to the development of criticisms of the traditional, and provision of alternative, paradigms of production management. These criticisms have resulted in the specific call for research into the control of production by a panel of leading American teachers of production-operations management.

The critical stimulus for this thesis came when I observed the tangle of control systems used in the production function of a major British manufacturing company. The Production Manager was responsible for equipment costing over £50m. and had a substantial workforce under his authority. He worked within a hierarchy of many control systems; some designed to assist his control, many others to monitor his level of control over the department's performance. Yet, despite, or possibly because of, these many control systems, he faced problems of late delivery, variable quality and adverse cost variances. I became increasingly aware of the high level of diffuseness in the managerial control of production. A substantial part of this control of production was formally instituted outside the hands of the Production Manager. Reflecting on the above, and on my other experiences within manufacturing industry, I became increasingly aware that such phenomena were not uncommon and began to question whether in some way their familiarity might mask their significance. I was also aware that the classical management control and production management literatures did not offer adequate answers to this type of question.

The need for such research has been recognized as an important area by Miller & Graham (1981), who report the findings of a panel of leading American production management teachers, as claiming that:

> "An important research need of the 1980s is the integration of operations control with the firm's competitive strategy."

They suggest a number of areas where such research is considered to be important. Of particular relevance to this thesis is their call for research which advances the 'integration of operations control decisions with the competitive strategy' and which similarly leads to improvements in the 'design and implementation of manufacturing control systems.' They also call for further research to be undertaken in the field of operations policy, thus recognizing the important 'linkage between the policy and control' areas of interest. Voss, at the U.K. Workshop in Productions/Operations Management (1983), similarly argued for greater research into the area of manufacturing policies which could link operational and senior management. Abernathy et al. (1983) indirectly support this theme when they argue that much of the Japanese competitiveness in the automotive industry has been based on '...diligent control of the whole system of production'. Similarly, Jaikumar & Bohn (1984) and Bohn (1984) have highlighted the need for developing a 'dynamic approach to production management' and for increased rates of 'systematic learning' within the production function.

The fundamental question arising from my observations led me to the general hypothesis that:

> The paradigm of manufacturing control in the U.K. literature and practice represents a restricted, (often unitary), perspective of the wider range of choices that exist. The traditional paradigm, which is generally practised in the absence of a manufacturing strategy, significantly underemphasizes the importance of systematic incremental improvement, as part of the production managers' role in the control process. Production managers need to take a more proactive role in achieving control of production. This role should emphasise the importance of achieving control through improvement of the design of the operating system in ways which reinforce the firm's long term goals.

The issues raised by the above hypothesis have extensive significance for both the practice and teaching of Production/Operations Management. The aim of my research was to develop a framework of the processes of controlling and improving production performance, to identify the roles of senior managers, staff and production managers and to reveal the factors that influence the movement of a plant from lower to higher levels of the framework.

2. REVIEW OF THE LITERATURE

2.1 THE PLACE OF CONTROL IN MANAGEMENT LITERATURE

Control has occupied an important place in production operations management (POM), since at least the era of Scientific Management. Using the term both in the sense of power and authority and of control systems, Taylor (1947) advocated taking:

> "...the control of the machine shop out of the hands of the many workmen, and placing it completely in the hands of the management, thus superceding 'rule of thumb' by scientific control".

Giglioni & Bedeian (1974), reviewing the developments in the theory of control between 1900-1972, show control to be a continuing theme in the wider management literature. The interest in control is so diverse that only a brief review of its more immediate influences on production management thinking are covered. Although a long running theme, the interest in control has varied, with particular interest being expressed in the 1920s, 1940s, 1960s and early 1970s. The 'general management' theme of the immediate pre and post war periods was summarized by Brech (1948), it in turn being replaced by the 'management process' school, in the 1960s & 70s as exemplified by Koontz & O'Donnell (1972), who sought to identify sets of principles for the overall management process. Control, although only one of five principles to be followed, has according to Child (1977), 'generally received the lion's share of attention'. Although all five steps were linked, planning and controlling were represented as two sides of the same issue, with planning referring to future events and control, to correction to the plans.

Additionally a number of papers appeared in the 1960-70s proposing concepts of control, Jerome (1961), Bonini et al.(ed.) (1964), frameworks of control, Anthony (1965), Woodward (ed.) (1970), detailed principles of control, Koontz & O'Donnell (1972), and mechanisms of controlling, Mockler (1972). Anthony's (1965), classification of control, into three levels, strategic planning, management

control and operational control, has become widely adopted, in decision support systems, Keen & Scott-Morton (1978), and accounting, Kaplan (1982). Woodward's (ed.) (1970) view of the relationship between control processes and the separation of design and execution of controls, has been used by social scientists such as Storey (1983). Anthony's and Woodward's frameworks both enlarged the meaning of control, to embrace much of the 'planning' component of the management process school.

Only limited evidence is available of the direct impact of behavioural science on production management concepts of control, Thompson (1967), Ouchi (1977). Other indirect influences have been via work design and accounting, Perrow (1967). From the industrial relations perspective Storey (1983) makes important links between Etzioni's (1964) 'power & authority', and the mechanisms used by management to control plants, and thus with industrial engineering and accounting. However, the decision was made not to develop this theme. That this places the thesis on the side of management, rather than worker control, is accepted as a consequence of this choice.

The thinking of a number of the workers in the field of control has in turn been influenced by developments in systems theory and cybernetics on both the concept and mechanisms of control. The diversity of backgrounds of those studying control has added a wide variety to the approaches adopted and significant differences in the conceptual frameworks used.

The link between accounting and control has at times been so strong that control has on occasions been treated as being synonymous with accounting, Giglioni & Bedeian (1974). The traditional interest in budgetary systems, Argyris (1952), Stedry (1960), Hofstede (1968) has, in recent years, been expanded by Hopwood (1976), Kaplan (1982, 1984a), and Macintosh (1985) to take into account ideas from a wide variety of the earlier schools of thought.

The wide scale recognition of the concept of manufacturing strategy, as advocated by Skinner (1978) and the upsurge of interest in Japanese manufacturing by the West, has led to a change in the essentially Taylorian perspective, derived from scientific management, the latter's concentration on procedures and mechanisms of control being what Drucker in Bonini et al.(1964) termed 'controls not control'. Skinner and subsequent authors, Hayes (1981), Wheelwright (1978, 1981), Hayes & Wheelwright (1979a & b, 1984) and Hill (1980, 1983, 1985) have widened the debate. Similarly, Japanese oriented literature, Schonberger (1982), Hayes (1981) has reflected a number of important differences in the concept of control of production. Some limited transfer mainly at a conceptual level has occurred from systems / cybernetics, Constable & New (1976), Wilson et al. (1983), Chase & Aquilano (1981) into the production management literature, but there has, in general, been little interchange from the wider research and discussion into the POM literature.

2.2 DIFFERENCES IN THE MEANING OF CONTROL

The variety of contributors to the debate has led to a diversity of meanings of control. These range from Fayol's (1949) monitoring, Etzioni's (1964) power & influence, Jerome's (1961) directing & coordinating, Mundel's (1967) control systems. One of the major distinctions has been between 'control over subordinates through the direction of their activities', compared with 'control in the evaluation of the outcome of an activity and the making of corrections when necessary', Giglioni & Bedeian, (1974).

Drucker in Bonini et al.(1964) drew a distinction between control and controls. He argued that control was concerned with the state of an (operating) system in relation to its environment and purpose, and controls were the means of manipulating the performance of an (operating) system. This led him to emphasise the importance of well designed (operating) systems as important elements in achieving a state of control. He also claimed that a number of the difficulties in

control arose from an undue emphasis on control systems. Thus, in Drucker's terms, control is associated with the ends sought by managers, while controls are to do with their means of achieving these ends.

Mockler (1972) claimed that in addition to the ambiguity arising from the variety of meanings of the term control, the subject lacks a coherent 'body of theory and principles to which executives can turn for guidance'.

2.21 Systems Theory/Cybernetics and the Control of Production

Mockler's view that 'control' lacks theoretical underpinning contrasts with that of the cyberneticians. They claim that cybernetics offers a framework for the study of

> "...all forms of behaviour in so far as they are regular, or determinate , or reproducible", Ashby (1956).

He also claims that it affords a basis for dealing with

> "...complex systems, where the complexity is too important to be ignored".

Beer (1969) makes the direct claim that theirs is a science of control dealing with large integrated systems. He considered that 'the same fundamental principles of control apply, and the same control mechanisms work' (within animate and inanimate systems). While large, these claims need to be examined, as they bear directly on the forms of control problem commonly faced by production managers. This is reinforced by the recognition by leading POM writers who recognize the importance of, and difficulties arising from, the complexity of production systems, Constable & New (1976), Hill (1985). Wilson et. al. (1983), reporting the findings of N.A.T.O.'s Advanced Research Institute's conference on 'The Efficiency of Manufacturing Systems', seek to demonstrate the practical value of systems research for the management of production. Checkland, in Wilson (1983), argues that the critical systems' issue in production is linking the production sub-system with the other sub-systems in the firm. This view is consistent with that of

Constable & New (1976). One 'systems' concept particularly relevant to modern production management is that of 'homeostatic control'. This refers to a condition, whereby the system retains its state (of stability), while adjusting to changing environments, Ackoff (1971).

2.22 Social Science Research and the Control of Production

Social scientists have adopted a wide range of perspectives about control. Two of their areas of interest are particularly relevant to this study, the concepts of control and the means of achieving control. The important theme of social control falls outside the remit of this work. Much of the work in the field of control has been conducted in the manufacturing arena; Woodward's (1965, 1970), initial study of the association between technology and organization structure, and the later studies of control systems. The Aston studies in the 1960s were an attempt to test and expand Woodward's earlier work. The insights of another of the 'technology' school of theorists, Thompson (1967), have had an impact on the formulation of the thinking of production management authors. His emphasis on uncertainty and the need to protect an organization's 'technical core', have been incorporated in the framework of control in some parts of the POM literature, Adam & Ebert (1978), Wild (1980).

Woodward et al.'s (1970) examination of control processes in a variety of manufacturing companies provided a number of important insights into the process of controlling production. Reeves & Woodward in Woodward (ed.) (1970) identified as a key factor the impact of changes in the nature of the control process on the progressive separation between the staff functions who design control systems, and line managers who execute the controlling act. Thus, as the control process moved from personal to mechanical, the separation grew. Another member of this research team, Klein in Woodward (ed.) (1970) considered that this differentiation would grow 'as modern management techniques develop and become more widespread'. She identified three different significant manag-

erial activities for operating and controlling, as:

"(a) the setting up of a workable system for production or service;

(b) the maintaining of the system, planning the work, coordinating the materials and services needed, keeping quality and cost within acceptable limits, and so on;

(c) improving the performance of the system and improving the system itself."

She maintained that 'the real challenge lay in improving the system itself'. Efforts in this area, it was contended, were likely to be seen, (by management), as less urgent than those in either group (a) or (b). Klein's theme of improvement (or at least adaptation) has a more central place in organization theory and sociology than in manufacturing literature. A link can be made with controls via their use as instruments for learning or for establishing compliance, Jerome (1961), and Newman (1975). Jerome in particular emphasised the need for increased attention upon the use of control systems as a means of learning how to improve performance.

Mintzberg (1973) revealed that managers typically spend a major part of their time acquiring and filtering information, as part of their exercising control. This information was typically gathered from a wide variety of sources and contained a considerable proportion of 'soft' data, obtained in informal discussions, meetings and rumours.

2.23 Accounting and the Control of Production

Accounting has many links with control, which cannot be explored in this thesis. This review is limited to a small, but growing sub-section of the wider accounting literature on control. Earlier writers have tended to treat management control as synonymous with financial control, Kaplan (1984b). He contends that such perspectives reflect the nature of competition in an earlier period, when price, and thus costs, were perceived to be the critical factor. While not rejecting the value of 'financial' measures of performance, in the process of

control, he recognises the need to embrace a wider set of competitive factors, which also need to be the subject of control, and thus are subjects for information systems. Such changes in approach, he predicts, will be difficult to accomplish because they are based on perspectives which have been practised for sixty years and have thus become institutionalized into 'professional' thinking.

Additionally, much of the accounting literature has been concerned with the control of plants and/or divisions by corporate executives. This topic lies outside the domain of this research, which is limited to control within the plant by its local senior management and the subordinates responsible for production. However, it is interesting to note that the ratios concerned with production, in the well established system of interfirm comparison, are restricted to measures of efficiency.

Behavioural scientists such as Argyris (1952) have undertaken a number of early studies into budgetary control systems, which have become integrated into the accounting literature. Arising from his research into budgets in a number of manufacturing plants, he concluded that budget supervisors were:

(a) operating the control system in a policing mode of control, and since being primarily concerned with 'adverse' variances, looking for things that were 'wrong'.

(b) reporting these 'errors' via the chain of command to their superior, with the foreman in whose department the adverse variance occurred eventually being informed of his 'mistake' through his own superior.

Argyris concluded that this system led to conflicts between foremen as they sought to put the blame for adverse variances on other departments. As a consequence, the plant manager's role became one of controlling the degree of inter-sectional conflict.

2.3 EVOLVING CONCEPTS OF CONTROL IN PRODUCTION LITERATURE

The impact of manufacturing strategy, Skinner (1978), Hayes & Wheelwright (1984), Hill (1985), Japanese competition, Shingo (1981), and the 'new paradigm',

Abernathy et al.(1983), on the Taylorian concept of control of production in the POM literature, was noted earlier. The concept of managing production that is emerging, has not yet been welded into a coherent framework. The impact on the approach to controlling production is similarly incomplete, although seven facets of the changes from the traditional to revised paradigm of control can be identified. They are changes from:

(a) tactical to strategic perspectives
(b) a static to dynamic view of production
(c) managing complex systems to managing the system's complexity
(d) fragmented to integrated control
(e) quantitative to managerial perspective of production
(g) a low to high emphasis on knowledge and learning within production
(f) adding stepped to incremental improvements

The changes in concept, outlined above, are highly integrative, and need to be considered as a whole. Nevertheless, their individual complexities force them to be initially considered as separate, if sequential issues.

2.31 From Tactical to Strategic Perspectives

Short term operational issues have historically dominated manufacturing management, leading to reactive responses to strategic issues, Skinner (1978), Hill (1985). Hill (1985) discusses the effects of a lack of a suitable language and set of concepts, on manufacturing managers taking a more proactive response. He argues that manufacturing's inherent complexity and the growing pressure to compete lead firms to adopt strategic short cuts within manufacturing. Recognition of the need for a strategic response from manufacturing has grown, mainly stimulated by the work of Skinner from 1966 onwards. Subsequently, major developments of the concepts have been made by Hayes (1981), Wheelwright (1978,1981), Hayes & Wheelwright (1984) and Hill (1980,1983,1985).

Although some similarity in the manufacturing strategies of companies in the same type of industry can be seen in "Manufacturing Future's Study", Meyer in Voss (1986b), the essence of strategy is tailoring a company's approach to its own circumstances. Processes for formulating a manufacturing strategy have been

devised by Skinner (1978), Hill (1980, 1985). Supporting this is Hill's (1983, 1985) 'profile analysis' which provides a way of examining the coherence between the facets of the manufacturing system and the strategy and also checks for inconsistencies between the functions. Both Skinner's 1978, 'key manufacturing tasks' (KMTs) and Hill's 1985 'order qualifying criteria & order winning criteria', (OQC & OWC) provide a basis for linking the process of control with corporate priorities. Both approaches help avoid the danger of 'simplistic measures of performance' warned about by Skinner (1978), and help overcome the 'excessive concern with short term measures by both line and corporate managers', Hill (1985), New (1986). Some of Skinner's (1966) earlier ideas implied a retreat from mass production, in the face of increased competition, suggesting that American producers should:

> "...replace the techniques, skills, facilities and even managers of an already outmoded concept of production."

This was subsequently countered in later publications on manufacturing strategy, where he demonstrates that firms could adopt a proactive approach to manufacturing by harnessing their production into a 'corporate weapon, as distinct from a corporate liability', Skinner (1969, 1978). Manufacturing strategy links corporate strategy and operational systems, by concentrating the total manufacturing system on the company's key manufacturing tasks, Skinner (1978). A critical factor in the way manufacturing strategy affects control is through the integration of the specialist functions to achieve coherent goals, which support the firms' competitive priorities. Hayes & Wheelwright (1984) claim that:

> "Again and again we have found that the root cause of a 'manufacturing crisis' has been that a business's manufacturing policies and people - workers, supervisors, and managers - have become incompatible with its facilities and technology choices, or that both have become inconsistent with its competitive needs. Even more subtly, facilities may still be consistent with policies, but the manufacturing organization that attempts to coordinate them may no longer be doing its job effectively."

The absence of an effective manufacturing strategy leads functional managers to make decisions, which although individually small are collectively significant for the future direction of the company, Twiss & Weinshall (1980).

Manufacturing strategy affects the controllability of a plant by reducing the level of complexity via simplification through the 'plant within plant' and 'focus' concepts, Skinner (1978), Hayes & Wheelwright (1979a & b, 1984). Hill (1985), in particular, links focus and complexity, claiming that although some complexity is unavoidable in manufacturing, appropriate forms of 'focus' can significantly reduce its level. He argues that most plants do not recognize the extent to which complexity can be avoided and improve their costs and reduce their level of bureaucracy. The 'focus concept' thus suggests that the state of control and level of performance of a manufacturing system can be influenced by manipulating the product/process matrix, Hayes & Wheelwright (1979a & b). In some circumstances an effective route to control will stem from the design of the 'techno' and 'infra' structures of the manufacturing process. The same authors also discuss the influence of the 'matrix' on the type of control system measures required. Manufacturing strategy also influences controllability through the issue of change and continuity. Manufacturing strategy recognizes the inevitability of change: both in direction and in level of achievement. Based on this recognition, it facilitates companies' abilities to exploit changes to achieve greater competitiveness. Changes in direction arise in order to meet new opportunities, and changes in level arise either in response to, or in anticipation of, competitive pressures. Thus, where protection of the technical core has led production to adopt the static concept of control systems used by Lockyer (1983), they would be at a disadvantage in bringing about these changes.

Maidique & Hayes (1984) pose the question of how companies should balance their efforts between continuity and change. Continuity which is consistent with the steady state model, is easier to control and to support with control systems. It is, however, more difficult to achieve a state of control or to devise suitable controls, in periods of change. They suggest that at the corporate level, successful firms tend to interface periods of stability with periods of '...tension, action and excitement...'. This implies a stepped change model of control and improvement. At the operational level, however, there is clear evidence that the

Japanese seek continuous, if rather small scale improvements, based on high levels of professional skill by their production managers, Schonberger (1982). Hayes & Wheelwright (1984) reflect this requirement in their emphasis on the ability of production to achieve improved performance over time. They reinforce Skinner's earlier warning that control and improvement in production should not be seen simply in terms of cost control / reduction. Instead it should be understood in the context of all the ways in which production performance can influence corporate success in the market place. Voss (1986a) similarly found that the 'dominant mode of managerial control was related to cost reduction and output maximization', despite the businesses having more market oriented goals. It follows that the state of control required to meet these criteria is both strategic and dynamic. The stepped and continuous incremental models of 'control and improvement' are not necessarily in conflict, with the latter being in between more capitally intense 'steps'.

The implications of manufacturing strategy are important for both the state of control and the design of control systems in production. In terms of 'control' the following issues arise. Wide differences in the type of control required by directors and foremen are revealed. Similarly, there are important differences in the control requirements between functional staff and line managers. In addition to those differences which can be attributed to the role of the manager concerned, there are, as Meyer in Voss (1986b) showed, differences due to the type of problem faced by the company in its particular economic and social contexts. This is reflected in the degree of deviation from standard that can be tolerated and the speed of response required if deviation occurs. The controls need to reflect long term improvement in production performance, Hill (1985). It would seem appropriate that senior management should monitor the rate and direction of improvement achieved within production. Similarly, at the operational level, the manufacturing control system should enable routine control to be exercised and improvement accomplished. Hayes & Wheelwright (1984), in their model of the four levels of manufacturing strategy, particularly emphasise the critical role

played by lower level management in accomplishing improvements in production performance. These improvements have to be monitored both for their direction and rate of progress. The managers achieving these improvements themselves need information in order to accomplish these goals. Hayes & Wheelwright also identify the difficulties of excessive use of short term, financially dominated, measures of performance. They claim that this directs attention to the near, rather than long term, performance. There is also a growing recognition by accountants that an organization's 'health' cannot be measured solely by its performance in terms of financial figures. Although individual manufacturing strategies have to be evaluated in terms of the needs of specific firms, there are, as Ferdows et al.(1986) show, significant differences in patterns between manufacturers in different continents. Ferdows et al. suggest that these differences reflect the extent of development in manufacturing strategy and manufacturing competences between these societies. Of particular significance to this research is their view that the current Japanese strategy emphasis on 'low cost' is the consequence of successfully managing to achieve high quality and good delivery and to implement process change. They contrast this strategic view of 'low cost' with the more immediate goal of 'low cost' found in European and American plants.

Ferdows et al.(1986) imply that the Japanese have had differing manufacturing strategic priorities over the post war period. Abegglen & Stalk (1985) give strong support to this perspective. Yet, in each of the phases, Japanese strategic priority has relied on accomplishing a high level of manufacturing performance which is effectively integrated with the corporate strategy. It follows that managing directors require appropriate control reports, which enable them to evaluate the critical elements of manufacturing's support of corporate competitiveness.

2.32 From a Static to Dynamic View of Production

The traditional model of production is based on high efficiency in an artificially stable environment, created by the organization protecting it from the vagaries of the market, Thompson (1967). The traditional POM literature does not describe things in systems' terms, but it clearly implies seeking efficient performance by achieving a 'state of control', while avoiding the investment needed to counter the effects of uncertainty and complexity. This emphasis on stability in production, when combined with a Taylorian concept of the 'one-best-way', tended to lead to control systems reinforcing compliance to static levels of performance, Jaikumar & Bohn (1984). In order to meet the changing requirements of the market place, major upheavals to the production system and its controls are made at irregular intervals. This can be either as a reaction or in anticipation of external factors. If the latter, the approach is similar to that of Maidique & Hayes (1984), who discuss major changes in a stepped manner. The emphasis in the traditional POM concept of attempts to maintain stability, and thus the use of static controls, can be seen in parts of the work of Constable & New (1976), Wild (1984) and Lockyer (1983). All these authors exhibit a variety of approaches in their material, yet they all, at various times, reflect the need for stability in ways which can reinforce static controls. Wild (1984), and Lockyer (1983), in particular use models of control taken from electrical and mechanical engineering. Lockyer, a proponent of the Watt regulator model of control for production, illustrates his view of control using a quote from Ewing on steam engines which emphasised their running at a steady, almost continuous pace. He states:

> "This comment on steam engines applies with equal validity to industrial organizations."
>
> Also
>
> "Industrial organizations today are just as much in need of <u>governors</u> as were the machines in the beginning of the Industrial Revolution."
> (my emphasis).

Lockyer's mechanistic approach emphasises controls not control, and stability

rather than change. Despite his mechanistic perspective, Lockyer also recognizes the significance of 'a state of control', as implied in Tocher's (1970) definition of control, which he recommends:

> " A production manager considers he has control over his works when he knows what will happen as a consequence of his actions and when he has sufficient choice to enable him to create the happening he wants."

The advent of increased competition in manufactured goods, and the development of manufacturing strategy as a means of responding to this requirement, had led to change rather than continuity being seen as the dominant requirement of the production function, even though the dominant paradigm is static. Increased competition in manufactured goods requires a greater emphasis on effectiveness and improvement, Abernathy et al. (1983). They consider that the traditional goal of efficiency was so wide spread by the late 1960s and early 1970s that:

> "With increases in size and technical complexity, it becomes more difficult to exercise direct hierarchical control. Production management can no longer have an intimate knowledge of the various specialized and complex processes that are intrinsic to the manufacturing task. To avoid the danger of losing control of the task, management builds into the organization impersonal processes of control to influence and regulate the work behaviour of those it employs."

Jaikumar (1984) and Wheelwright & Riggs (1983), also criticize these 'static controls'. The latter categorize firms into polarized groups, either adopting 'static' or 'dynamic' models. They claim that:

> "...most organisations end up close to one extreme or the other, and few find themselves in an in-between position for any extended length of time."

This polarization is attributed to the organization structures and control processes adopted by most companies. As noted above, the change in emphasis from static to dynamic, reflects an awareness of production's potential to contribute directly to corporate competitiveness. The traditional 'mechanistic' models of control are simply required to achieve planned performance, unaffected by competition. Abernathy et al.(1983), show that improved levels, and at times changes in direction, of performance are required from production systems. Thus static controls become inapplicable in competitive contexts.

The emphasis on the need for production systems to improve their performance and, as necessary, change their priorities, has hidden the important principle outlined by Thompson. Even in periods of dynamic change, stability within the production system is required. The problem is with the transformation of system stability into static controls. The 'systems' concept of dynamic homeostasis is of relevance here. It shows changes in performance can occur, and where necessary internal restructuring take place, without destroying the essential internal stability. Japanese systems of production appear to incorporate a number of the elements necessary to enable the joint pursuit of stability and improvement. The goal of stability, however, has not relied solely on protecting the production system from the uncertainties, within and without manufacturing. Rather they come from engineering the production technology and procedures so that all unnecessary complexity and uncertainty are removed.

We noted earlier that improvement in manufacturing performance can be achieved by either step or incremental changes, Hayes & Wheelwright (1984). Step changes generally come from major investments in the process technologies or infrastructural system. Incremental changes come from small scale manipulation of the existing technologies or infrastructure. The two approaches can be complementary, with incremental improvements being accomplished in between the step changes. Indeed, Ferdows et al.(1986) appear to suggest that the Japanese emphasis on incremental improvements helps them develop better process technologies 'in house'. However, the conditions necessary to accomplish a significant level of incremental improvements, are not consistent with those under the static control model, discussed in texts such as Lockyer (1983), and Wild (1984). The step and incremental routes to improvement require different sources of information. Similarly, senior management need to monitor different aspects of performance. Major step changes are likely to strengthen the position of staff groups as they liaise with equipment designers and suppliers. Incremental improvement, however, can be more strongly linked with line management.

Two forms of the incremental model have been considered. The first is a theoretical framework by Jaikumar & Bohn (1984), in which they propose a series of experiments to be conducted as a basis for improving the rate of learning and thus knowledge about the processes. The second form is much more empirically based, being derived from Japanese manufacturing practice.

The principles of how this has been accomplished are explained in the following sections, dealing with complexity, trade-offs, organization and knowledge / learning.

2.33 From Managing Complex Systems to Managing the Systems' Complexity

The traditional model of production is based on recognizing the complexity of the production system. Starr (1971) considers complexity to be a critical factor in the management of production:

> "The core of operations difficulties is that there are so many different problems encountered each day and so many reasonable arrangements (billions, trillions) for meeting quality, quantity, schedule and cost with differing kinds of satisfaction."

The traditional model of the production manager's task recognizes a trade-off between coping with complexity and performance levels. Where the task complexity exceeds the capability of the production system, a trade-off in performance is, at least temporarily, inevitable. This may lead production management into 'fire fighting' their problems in the short term. Hutton & Lawrence (1978, 1979), Daly et al.(1985) have noted that British production management are more likely to adopt this response, than their Continental counterparts. A number of alternative approaches exist. One discussed in the organizational literature is to use standard rules and procedures to restrict the effects of uncertainty, and thus complexity, Galbraith (1973). This could take the form of customer queues, restrictions on the rate of product development, product / component standardization etc. Where competition is effective, these devices to restrict complexity work against the needs of the market place. The result is often expensive

redesign of the production system and management procedures. The classical case of this is the year long delay to Ford's production, when they eventually responded to General Motors' product innovation, Abernathy (1978). The traditional POM paradigm is reactive. It seeks to manage in a complex world, with little emphasis on proactively changing the conditions that led to the complexity. Thus, in order to handle the prevailing complexity, management are forced into developing increasingly sophisticated information systems. Ferdows et al.(1986) found that American manufacturers were significantly more disposed towards using advanced MIS than were their Japanese counterparts, who preferred to emphasise greater simplicity.

An alternative, more proactive approach, is via manufacturing strategy. There the emphasis might be on the focus concept, plant-within-plant concept and / or building the capability of the techno and infrastructures to respond to the market place requirements. Part of this process may lie in explaining to others, (e.g. marketing and financial staff), the significance to production, when high levels of complexity are demanded. This includes helping them to recognize the likely effects on the level of performance. Hill (1980), while accepting the complex nature of production, argues that:

> "...operations managers have failed to explain the complexity they control in a way which helps others to understand the issues and trade-offs involved."

This view reinforces the idea that the design of the manufacturing task provides a critical and possibly overlooked vehicle for accomplishing the desired state of control within production.

Skinner's (1978) '..the outmoded concept of ... mass production' and Abernathy's (1983) '..the de-maturation of production', both discuss the idea that the conventional paradigm of large volume manufacturing of standardized products, with its high complexity, is under challenge.

A third highly proactive approach to the management of complexity is found in

the Japanese system of production management. Their emphasis is on reducing the factors that lead to complexity, so that the system can be managed effectively. This enables them to combine internal stability in the production function and to accommodate the need of the market to be dynamic. The Japanese also place considerable emphasis on the reduction of uncertainty, which takes many forms. These range from plant maintenance systems that ensure reliable machine availability, quality systems that provide predictably high quality products to the next work station (as well as the customers), to employee absenteeism / turnover levels which ensure a constant availability of skilled workers to meet the evenly loaded production schedules. The JIT and KANBAN systems also aim to provide predictable performance, within the plant and from suppliers. A link can be made between these efforts to reduce complexity and the small scale incremental changes discussed above. Many of the improvements have come from either observation of problems on the shop floor or from deliberately exposing the line to increased difficulty to discover its next weakest link, Schonberger (1982). As will be discussed below, this radically different approach to tackling complexity has significant implications for the way problems are resolved, the information / knowledge required in the production system and for the relative roles of the members of the staff functions in the firm. The critical characteristic of the Japanese system of POM, in terms of its effect on control and controls, is the (implied) emphasis on 'the state of control' through engineering the technical and managerial systems. This, in turn, simplifies the task of the control systems. Ferdows et al.(1986) observe that the Japanese manufacturers place greater importance on seeking improvements in performance via the role of 'simplicity' than do their European and American counter parts. The latter still place much greater emphasis on the design of MIS, with the stress on controls rather than control. Their comparisons show that while all the groups acknowledge product quality as a critical component of competitiveness, it is the Japanese who prioritize process yields etc. Such achievements are closely linked with development of simple and robust manufacturing systems.

2.34 From Fragmented to Integrated Control

A further consequence of Taylor's (1911) attempt to remove '..control.. out of the hands of the ..many workmen ..in..(to) the hands of management..' has been the growth of staff specialists.

We noted the view by Checkland in Wilson et al.(1983) that specialists lead to conflict between organizational sub-systems, and that optimization of one sub-system could lead to sub-optimization of the overall system. Checkland considered this to be the critical issue affecting systems' theory in production management. To limit this effect, restrictions can be placed on the extent of changes made to these sub-systems. This constraint is important when coordination of the whole is becoming more critical than the maximization of any one of the sub-systems, Constable & New (1976).

Woodward (1970) showed that as control systems become more mechanistic, there is a tendency for functional staff to take over their design and operation. The result may be the isolation of production management into users, rather than initiators of control systems for their own functions. It may also lead to a growth in 'controls' as staff seek to prove their value to the organization. Abernathy et al.(1983) support this view, claiming that, where organizational size is large and complexity high, line managers become increasingly distanced from the processes of control.

Among the many providers of control information, three manufacturing functions, industrial engineering, production control and quality control, are particularly relevant to this thesis. Accountants provide a fourth specialist function critical to the control of production, but do not form part of this study. Generally, they act outside the umbrella of the manufacturing structure, even when providing internal 'operating' information. As Argyris (1952) highlighted in the 1950s, staff specialists, (in his case budget supervisors), are likely to report to

senior management variances between performance and budget as 'mistakes', thus, not only triggering line and staff conflicts, but also line - line conflicts as the pressure to avoid these 'mistakes' occurring on their reports leads managers to 'blame' other line managers for the conditions that 'made' the variance inevitable.

The line and staff structure is so ingrained into the fabric of manufacturing organizations, that, despite acknowledging the problems that occur, most writers still, if reluctantly, support the status quo. Constable & New (1976), while generally reflecting the traditional line and staff structure, advocate the importance of operations managers acting as synthesisers of the overall system. Similar views are expressed by Hill (1983), who, although generally taking a strong production emphasis, still supports the line and staff approach arguing that:

> "In order to control this relatively large system, the POM tasks are broken down in functions each with their own set of activities."

Discussing the question of analysis, he comments that:

> "This is often best accomplished through specialization, which is currently used by most organizations as the basis for controlling their activities."

He balances this by warning of the danger of specialists who perceive the organization's interests from their own, often narrow, point of view. Thus, like Constable & New, he calls for the operations manager:

> "..to build back these functional views into the total system in order to ensure the overall system's performance is improved."

Hill's approach is best understood in the context of his advocacy of manufacturing strategy. Without the support of such a strategy, few production managers are likely to take the proactive stance he recommends. The development of manufacturing strategy has stimulated a re-examination of the role of specialists and the control systems they tend to dominate. In particular, the infrastructure component of manufacturing strategy has led to a new level of clarity about the role of specialist staff. Hill (1985) points out the need for specialists to have:

> "..a shared awareness of what is required in manufacturing, if it is to best support the current and future needs of the business."

He points out that this shared awareness often does not exist, as staff functions have grown in size and power and no longer (in some cases) report to senior manufacturing managers. He considers this has led to a loss of integration at the strategic level, which cannot adequately be made up for at the tactical and operational levels. Should this be so, it suggests that this reporting to higher organizational levels, outside the manufacturing hierarchy, leads from the provision of information to support the line manager towards information which reports on the line manager's performance. There is little doubt that the majority of accounting systems report on the efficiency, rather than effectiveness, dimensions of the manufacturing manager's task. This emphasis on efficiency is in general inadequately countered by other staff specialists' control reports reflecting the wider competitive criteria discussed by Skinner (1978) or Hill (1985).

Hill (1985) builds on Skinner's (1978) earlier theme of enhancing the infrastructure to ensure that all functions integrate with the manufacturing task. He is particularly concerned that the staff functions and resulting control systems recognize the complexity of the manufacturing task:

> "Firms need the function and specialist capabilities to make sense of the complexity. Without these inputs, firms cannot reach the level of effectiveness necessary to meet today's competitive pressures."

Schonberger (1982) gives an alternative to the traditional POM perspective, when he outlines the Japanese approach to the respective roles of line and staff managers. He states that:

> "...the Japanese rely little on staff specialists. The worker and managers are the focal point, and innovations concerning productivity and quality management are nurtured on the shopfloor, not in someone's office."

He contends that Western countries emphasise the staff role, leading to '...a closed ended approach to improvements in performance.' He considers this has led to one-time 'step changes' in productivity. This is contrasted with the Japanese system, with its greater emphasis on small incremental changes, which tends to trigger other rounds of improvements. Hayes & Wheelwright (1984) support this perspective.

The dominance of technical experts is considered by Skinner (1978) to be a major source of distortion in firms; firstly through over emphasis on the tactical at the expense of the strategic issues, and secondly from adopting narrow functional perspectives of the firms' activities. He contends that:

> "For 50 years management relied on efficiency experts trained in the techniques of Fredrick W. Taylor. Industrial Engineers were the kings of the factory."

He also discusses the adverse effects these industrial engineers had on manager-worker relations which at that time were not adequately recognized.

Increases in the number of, and sophistication of, the staff based control systems has generally led to concern over high ratios of total employees to direct operatives. This has come from reductions in direct labour numbers and increases in staff levels. While not intrinsically wrong, such phenomena, taken in conjunction with evidence that British ratios are generally higher than those obtained by competitor nations, N.E.D.C. (1978), and a lack of evidence that such ratios have provided a competitive advantage, led to a questioning of the emphasis on staff based controls. Not only are there difficulties associated with measuring and controlling indirect and staff costs, compared with direct labour costs, but as Skinner and Hill showed, there are very real risks that these staff functions can mis-direct the control efforts.

2.35 From a Quantitative to a Managerial Perspective of Production

The growth in complexity of manufacturing systems, combined with Taylor's emphasis on scientific management and the expansion of staff specialization, is reflected in the use of the quantified methods used by the industrial engineers, as noted by Skinner (1978). The development of work study and later operational research led in an integrated form to industrial engineering, which sought to adopt the more routinized quantitative techniques of the operational researchers to recurring problems in production. This strengthened the quantitative orient-

ation in production management, Barnes (1963), Mundel (1967). The industrial engineering and operational research approaches tended to dominate the content of courses in production (management). Delmar (1985) reports that even as late as the 1960s American Colleges and Universities based their production management courses on 'a combination of Industrial Engineering and Business topics'. He contends that even this was approached from a staff perspective and often taught by those versed only in theory. This emphasis on quantification reflected American perception of production operations management as an amalgamation of industrial engineering and operations research, Bohn (1984).

An example of the use of simple quantified methods in examining recurring problems of control is the 'economic order quantity' model, Harris (1915). It seeks to optimize the trade-offs in performance between two or more conflicting factors. This approach eventually led to the modern systems in production control. Subsequently in the late 1920s and 1930s major developments in quality control arose, reinforced in the immediate post war period by Juran (1945) and Deming (1950). Increases in complexity from company size and the need for higher performance led, over the years, to the development of increasingly sophisticated quantitative methods. This led in some cases to 'Operational Research' groups being the primary teachers of production management.

The early developments in work study were most significant in terms of the control of labour, through work measurement and in terms of management's ability to stipulate the means of accomplishing the prescribed task, Taylor (1911), Gilbreth (1911). More recently, under the influence of manufacturing strategy, the emphasis has moved to the managerial rather than the quantitative perspective, Constable & New (1976), Hill (1980, 1985). The American literature tends to seek an amalgamation of the quantitative and managerial perspective, Buffa (1983), Chase & Aquilano (1981), Delmar (1985), Schroeder (1985). Similar quantitative emphasis can be found in some British texts, Lockyer (1983), Wild (1984). One factor influencing American texts in adopting a more quantified

emphasis is the need to meet the criteria of the Collegiate validating POM programs.

Manufacturing strategy has widened the perspective, from optimising trade-offs at the operational level to consideration of the effects of these 'infrastructural techniques' on companies' abilities to compete. It remains a trade-off concept, but at a strategic level. The staff functions, designing and operating these planning and control systems, are now required to achieve compatible goals, focused on supporting manufacturing's efforts to satisfy the corporate strategy.

Japanese manufacturing practices reflect a different perspective on the use of quantitative techniques. This is illustrated in a comparison between EOQ, to find the minimum combined ordering costs and holding costs, with JIT, which minimizes the size of batches. JIT does not deny the mathematics of EOQ, rather it challenges the assumption of a fixed setup time, in order to accomplish the smaller batch sizes wanted by the Japanese. Attention is directed to reducing setup times, rather than mathematically optimizing the existing setup and carrying costs. The focus is thus shifted to the manufacturing process and the shop floor as the basis of control. Similarly, modern quality control has put emphasis on the design of the process as the basis of control and improvement, Ford (1984a,b & c). This is not because the Japanese are unskilled in the quantitative techniques, but because they put their emphasis on production systems which lead to greater simplicity, and thus less complexity. As a consequence they do not require the same reliance on quantitative techniques, Schonberger (1982).

2.36 From a Low to High Emphasis on Knowledge and Learning within Production

The above has revealed a distinction between the American and Japanese approaches to learning. Abernathy et al.(1983) claim that American manufacturers find it difficult to:

> "...(build) ..and guide an organization that is altogether responsive to an ongoing process of learning - about markets about technology, about production systems and about linkages among them."

Conversely, Hayes & Wheelwright (1984) note that the Japanese place considerable emphasis on continually building the skills of the workers, who are trained to:

> "... continually search for new ways to eliminate potential disruptions and improve overall performance."

They also report a similar difference in skills between North American and German production management. The Germans are considered to put much greater emphasis on achieving a high level of technical competence in the lower levels of the plant's hierarchy. Daly et al.(1985) support the same perspective with their comparative study of German and U.K. foremen, with the former being primarily technically skilled, although also having some managerial training. The emphasis on developing the skills of low level members of the organization helps to bring about a different form of control, because these skills contribute to reductions in the complexity and uncertainty within production, thus reducing the need for controls. The priority in the U.K. appears to be historically the reverse of the German and Japanese approaches. The shop floor skills are treated as less important than staff skills. It can be argued that this lack of emphasis on skills in the U.K. creates a self fulfilling situation, where staff become essential. However, this lack of skills in U.K. manufacturing has received renewed attention, suggesting that 'training', at least in a few plants, will be given much greater attention than previously, Goodridge (1986).

Not only is the Japanese approach based on learning, but, like the German model, improvements are sought lower down the hierarchy than in the American model. Hayes (1981), in a now famous observation, reveals that the Japanese '..pursue the last grain of rice', indicating that they seek to learn and improve beyond the point considered economically justifiable by American manufacturers. This commitment to continual small scale improvements is supported in his reference to them as '...smart and industrious - and never satisfied.' To support this commitment to learning, Jerome's (1961) view that senior management must treat variances as a source of learning and not simply as mistakes, is likely to be a

critical factor. Hayes & Wheelwright (1984) claim that the Japanese differ (from American managers) in that they are more supportive to workers who report 'mistakes'.

Learning needs to be linked to knowledge about the critical issues and not sought for its own sake. Hayes (1981) and Wheelwright (1981) report different views on Japanese practice. Hayes considers that they: '...regard all problems as important', while Wheelwright considers that they:

> "...pay a great deal more than lip service to the goal of making production and strategy mutually supportive."

Much less emphasis on learning is found in Western based production management literature. Some recognition of the need for improvement is given in Schmenner (1981), Chase & Aquilano (1981); the latter considering 'updating' indicating learning leading to periodic discrete step changes in performance. Conversely the Japanese emphasis is on continuous learning and improvement. These improvements are reported to arise from a combination of mastery of traditional knowledge and the development of new knowledge to overcome the traditional limitations upon performance, Shingo (1981).

The importance of knowledge and learning in bringing about improvement is not new. Taylor (1911) promoted increased knowledge via scientific management and Jerome (1961) emphasised its importance in executive control, advocating the design of control systems which enhance management's ability to learn. Similarly Rosenberg (1982), claimed the 'capability to use technical knowledge' was the distinguishing characteristic between static and dynamically oriented firms. Technology in this context is not necessarily sophisticated machines and computers, but is used in Perrow's (1967) wider sense, which embraces knowledge.

The training given to production managers and workers in control and improvement is critical to the acquisition of knowledge and thus learning. Studies reveal considerable differences in the levels of supervisory training used in the U.K. and

West German companies, Hutton & Lawrence (1978, 1979), Sorge & Warner (1980), Daly et al.(1985). Taken collectively their work supports the view that supervisory training in the U.K. receives substantially less emphasis, both in terms of engineering skills and managerial practice. The view of a German plant manager, as reported by Daly et al.(1985) is considered significant in this context.

> "Three quarters of all improvements in productivity are achieved through ensuring an adequate documentation of exact machine-setting; ensuring that all parts are available and are of the right dimensions; that all drawings and measuring devices are available; that all involved know how to do the jobs; that the product design is appropriate; that the manufacturing and operation sheets are well prepared before work begins, and that no corrections will be necessary as production proceeds. This clear work method has to take place within a clean factory with clean machines and in an atmosphere of order and discipline. These are the responsibilities of the Meister and engineers; if unforeseen interruptions take place, these men are sufficiently well trained to know how to analyse the problem and act accordingly."

Much of that quoted by the German plant manager might be simply described as establishing good practice. However, such statements should not be lightly dismissed unless there is clear evidence that such 'good practice' is already clearly and effectively followed in U.K. plants.

The new emphasis on learning represents a challenge to the conventional view of Thompson's (1967) concern to protect the technical core. New knowledge destroys the capital invested in old knowledge and skills, Hayes & Wheelwright (1984). The static model is of controls protecting existing capital and knowledge, but at the cost of reduced learning, and thus limiting production's capability to compete in new ways.

A common theme in manufacturing strategy, the new paradigm and Japanese manufacturing techniques is the importance of knowledge and learning. Skinner (1978), and Hill (1980,1985) both showed that improvements need to support the critical manufacturing tasks if they are not to be simply changes.

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Norman & Bahiri (1972), reporting the earlier work of Swan in 1966, show that

a lack of knowledge, at executive level, about modern techniques and suitable information, had been a major contributing factor in 50% of business failures in the Yorkshire / Humberside region. Fourteen years later Lockyer et al. in the Bradford study (1980) showed that there was still a substantial shortfall in management knowledge on this topic.

2.37 Adding Incremental to Stepped Changes in Performance

Hayes & Wheelwright (1984) discuss '...an inherent bias against small incremental improvements..' in the way general managers evaluate changes in their manufacturing systems. They argue that general managers need to recognize that much of the improvement in technology depends on making a large number of relatively small changes in working practices, and much less from a few major technological breakthroughs. Such progress requires a series of small steps based on knowledge within the firm rather than from without.

The specialist field of quality control affords powerful insights into the basis of control. Although it identifies the necessity of achieving compliance with standards, it places great significance on process control as the means used to achieve the results. The emphasis in effective quality control is ensuring that the productive system is in 'a state of control', by linking this with the concept of 'fitness for use', which is a dynamic, customer oriented approach. There is the implicit recognition that to be 'in control' the productive system has to respond to external changes in requirements. Thus, it must be capable of control by complying with the transient standards and 'in control' through adapting to higher requirements.

As noted above the Japanese companies place considerable importance on improvement and attention to detail, Abernathy et al. (1981), Hayes (1981), Wheelwright (1981) and Schonberger (1982). Three elements can be identified in the Japanese approach. The first is seeking radical solutions to traditional

production problems, such as JIT, KANBAN, Total Quality Control, Shingo (1981). The second is exercising traditional production skills such as improving setup times, plant layout, equipment design, and quality procedures, at exceptionally high levels of professional competence. The third is seeking improvements beyond the level considered economically justified by many Western companies, Hayes's (1981) '...the last grain of rice.'

One of the exceptions to the general lack of emphasis on learning as a component of the production manager's task is Chase & Aquilano (1981). Using a life cycle approach to POM they argue that it is important to 'update' the production system during its 'steady state' stage. Even here, however, the emphasis is on periodic reviews, which are implicitly staff led:

> "...the implementation of major revisions of the productive systems in the light of changes in demand, organizational goals, technology and management."

Even this relatively proactive stance appears to operate on a Taylorian premise that the current production system is correct for the current circumstances. They discuss updating only in terms of reacting to changes in circumstances. There is no evidence that such updating is seen as a means of initiating a competitive advantage through a superior capability. This view of adaptation contrasts with that of Klein, discussed earlier. Not only did she advocate smaller more frequent improvements, but she looked for a more proactive response within the production function.

2.4 EVOLVING PRACTICES OF CONTROL

Many of the changes in the concepts of control discussed earlier stem from advances in industrial practice. The following section examines the competitive pressures that have led to these changes, the form they have taken and the impact they are having on the practice of control.

2.41 The Competitive Pressures for Change

The implications of increased competition in manufactured goods has been widely recognized, Abernathy et al. (1983), Hayes & Wheelwright (1984) Schroeder (1985), as a major threat to existing practices of production management. The progress achieved by these emergent manufacturing societies is not a new phenomenon; the newness is the awareness of the challenge. The significance of this build up in competitiveness lies in the skills and competences that support the achievements, Hayes (1981). The recent wave of study visits to Japan reflect its progress in competitiveness and these have shown the depth in infrastructural effort needed to sustain such achievements.

Adachi et al.(1982) show that Japanese concern for quality and improvement pre-dated their rise as a world class competitor, after the second world war. They instance the effort in the 1920s of Mr.Ezoe of N.G.K. spark plugs to achieve American standards of performance. This included removal from the market of the company's entire output, in a period when '...a few defects were spotted.' So resolute was this pursuit of quality, that Mr. Ezoe was eventually removed from office by the military command for refusing to compromise quality to achieve higher output, during the second world war. While he might not have been representative of pre-war Japanese industrialists, there is little doubt that his modern counter parts would share some of this approach. This is not to claim that the Japanese have not harnessed technological and managerial transfer from the West. Adachi et al.(1982) trace many of the efforts at technological transfer in the automotive assembly and component industries and these include Graham-Page in 1937, Austin in 1952, and Rootes in 1952-3. They report a change in emphasis in technological transfers in the late 1950s, switching from products to equipment. Similar 'managerial' transfers have taken place particularly in the field of quality. The effect of Shewhart, Deming etc. has been extensively recorded elsewhere.

The search for knowledge from overseas sources was stimulated by powerful internal competition, Adachi et al.(1982), who reported the severity of price competition being so intense that the price of a Nissan Blue Bird in Japan declined from 700,000 to 500,000 yen in the period 1959 to 1965. Similarly, Shingo (1981) reports a long period of commitment to improvements and more effective control by Toyota, dating back to 1945.

The concrete levels of achievement of Japanese manufacturing have been documented in a number of sources. Abernathy et al.(1983) report new entrants to the 'pump' market developing products at 50% of the previous market price and thus over a five year period driving Ingersoll-Rand out of the Japanese market; similarly, they had shown (1981) Japanese cars being landed in the U.S.A. at 30% below American costs. Clarke & Banks (1983) support this latter perspective. Haydon (1980), a Ford executive, reported Toyota being able to achieve 'first run capability of paintshops at 95%, compared with Dagenham's 50%.' British Leyland (1985), five years later, claim to achieve a 90% capability. Haydon also reported inefficiency level comparisons of 49% at Ford and 20% at Toyo Kogyo.

2.42 The Forum of New Practices of Control in Production

Many of the changes introduced by the Japanese production systems can in retrospect be linked to the process of control. Critical characteristics are reductions in the operating system's complexity and removal of unnecessary uncertainty. Shingo (1981) outlining the 'improvement of process', highlights the multi-functional attack of the Japanese and identifies both the value analysis and industrial engineering as central vehicles in improving manufacturing processes. It should be noted that his reference to industrial engineering is closer in practice to British 'production engineering' than work study. Although reference is made to Gilbreth and use is made of the American Society of Mechanical Engineering symbols, the technological nature of the conversion process changes discussed are closer to production engineering than work study.

2.43 Aims and Mechanisms of Executive Control of Production

Executive control of production has been strongly influenced by the 'profit centre' model. However, a number of accountants consider this model to be inappropriate as a basis for the evaluation of production, as many of the factors determining profit fall outside the compass of production management. Cost centre consequently plays a more critical role in this context. Yet, as De Coster & Schafer (1979) discuss, this is an incomplete approach, as it only recognizes the efficiency and not the effectiveness of production. They advocate supplementary cost data, with other measures, which indicate the value to the plant from production's performance. We already know from quality control, Juran (1974) that value is assigned by the customer and is changeable through time. Constable & New (1976) discuss the evaluation of production's performance by senior plant management. They do not explicitly link evaluation with strategy, but instead they concentrate on a series of trends and ratios.

A consensus has emerged, however, in the manufacturing strategy and the new paradigm literatures, that production can and should form a major ingredient in many firms' corporate competitiveness, Skinner (1978), Abernathy et al.(1983), Hill (1985). Implicit in this recognition is the assumption that senior executives will seek to link the evaluation of production with their corporate objectives. Thus, the evaluation of production could be expected to include an explicit strategic perspective. Hill (1985) is clearly aware of the need for investments in manufacturing to be linked to the corporate and manufacturing strategies. He also identified a need to link the manufacturing task and the assessment of current performance. His criticism of the contribution of conventional accounting data to evaluating production performance is heavily based on the observations of Kaplan (1984a).

2.5 CONCLUSIONS

The literature review has revealed three approaches to the process of control in production. The first approach is more strictly a state of a 'loss-of-control', more commonly referred to as fire fighting, Hutton & Lawrence (1979), Daly et al.(1985). It occurs when production, failing to achieve necessary levels of performance, undertakes strenuous efforts to accomplish its immediate objectives. However, in doing so it moves from problem to problem, without resolving the underlying causes, resulting in the same cause giving rise to similar problems in the future. The second approach, represented by Lockyer's mechanistic models based on the Watt regulator, is known as the 'control and command model', Jaikumar (1984). It seeks to maintain stability of the production function and in doing so it resolves most of the recurring problems faced by the 'fire fighters'. However, because many managers perceive the production function to be complex, and in many instances do not see it as a strategic vehicle of competitiveness, they seek to maintain an essentially static level of performance, in between changes induced by staff groups. These step changes in production's capability to perform can lead to improved production performance, either through more advanced technology in production or through more sophisticated, often computer based systems of control, (i.e. MRPII). The third approach is based on the Japanese model of production management, in which small scale incremental improvements are made by production management and its staff to the manufacturing processes and control systems. These improvements are complementary to the larger, step changes in the second approach. They frequently lead to reductions in the level of difficulty in the manufacturing task, by reducing the level of uncertainty and complexity. The reduced level of difficulty is in turn taken back up in seeking to accomplish either revised tasks or higher levels of performance, which add to corporate competitiveness.

Although these approaches can be detected in the POM literature, there is little recognition until recently that alternatives existed to the lower level

approaches. Implicit within the progression through these approaches is that control is accomplished jointly through the mastery of the production process, as well as through the more commonly recognized control systems. While this was clearly recognized in the early period of scientific management, it has largely been neglected until the Japanese restored its application. Thus, production management theory has not adequately addressed a number of important issues:-

(a) What is the link between manufacturing strategy and control?

(b) What are the roles of managing directors and production managers in bringing it about?

(c) What, if any, differences in information are needed in the alternative approaches to control-improvement ?

(d) What, if any, differences in analysis are required between the approaches?

(e) What is the significance of training levels in production in successfully operating the higher level approaches to control-improvement ?

Thus, as Twiss (1986) suggested in an editorial looking forward to the future of Production Management in the 1990s, we are in a period of change in which the traditional paradigms are under challenge. The extent and means to which changes actually occur are examined below.

3. METHOD OF STUDY

3.1 PROBLEMS OF DESIGNING THE RESEARCH

The design of the research process was based on consideration of three issues. The first was the balance between techniques and the philosophy of control in production. A bias towards techniques would have facilitated challenges to specific mechanisms of control, while a bias towards philosophy would have facilitated challenges to the process of control. Second was the choice between a tightly consistent approach across all research sites, compared with a sequential development of the research process. The former would have enhanced the comparison between sites, while the latter offered scope for greater insight into the process of control, as I increased my understanding of the problems involved. The third issue was the choice between a narrow versus wide spread of research sites. The former would achieve greater depth in a few situations but would increase the difficulty of finding suitable examples of the expected variety of practices.

3.11 Techniques versus the Philosophy of Control

The control of production embraces both techniques and philosophy; both are important. Historically research in production management has tended to emphasise quantitative techniques such as Economic Order Modelling, Scheduling, Quality Control etc. Research concerned with the philosophy of control and with human behaviour and even strategic considerations, although equally important, has received less attention directly from production specialists. The development of manufacturing policy and the success of the 'Japanese philosophy' of production management has led to renewed interest in the philosophies and concepts underpinning the techniques of control.

Easterby-Smith in Chapman (1985) argues that different research strategies are needed for these approaches. He has labelled them 'hard' and 'soft' research. An important distinction between hard and soft research processes is the emphasis in the hard model on 'facts and figures', compared with the emphasis in the soft

model on the interpretation of facts and the role of the 'knower'.

This research adopted a bias towards the 'soft' approach in order to emphasise the managerial framework of control. Advancing the techniques of control, while recognized as important, was considered less significant than developing a framework within which the many approaches to the control of production could be understood and a path to the more effective approaches identified.

3.12 Consistent versus Developmental Research Processes

The aim of developing a framework encapsulating the various approaches to the control of production required that the data collection methods reflected both consistencies and differences in practices of control. The collection methods needed to reflect factors that were common and which differed between the cases in respect of their approaches to the control of production.

Adopting an entirely consistent approach would have led to three difficulties. Firstly, it would hide or minimize the impact of any differences in circumstances affecting the sites and thus their control process. This would be particularly noticeable in terms of the differing competitive goals set within the various sites. Secondly, a number of the concepts, noticeably those of the 'key manufacturing tasks' and the 'order winning criteria' had been designed to be used in prescriptive ways. These techniques had not been used or tested for use in the type of context to which they were now being put. Thus caution was required in their use. It was recognized that as these techniques were applied some learning would take place which would enhance the means of identifying the firms' competitive goals. Thirdly, there was the desire to progressively enrich my understanding of the nature of the problems involved and the desire to avoid missing new strands of the argument by a premature formulation of the research methods.

These objections were resolved by using a two stage research process in which the method of investigation was reviewed after the initial investigations. I was enabled to simplify the identification of the competitive goals by substituting the 'order winning criteria' technique for the 'key manufacturing tasks'. This was done with the permission of T.J. Hill, who showed me this approach in 1984, prior to its publication in 1985. The second stage of the research placed an increased emphasis on the knowledge base of the production managers and their means of acquiring updating. The emphasis was upon increasing the extent to which learning took place and the role of the control process on this learning.

3.13 Data Collection: Wide v. Narrow Spread of Sites

The choice between a wide or narrow set of research sites concentrated attention on the option of surveys versus case studies. Surveys have been widely used by industrial economists, Gold (1971), management scientists, Eilon et al.(1976), but less frequently by operations management researchers, with some notable exceptions, New (1976), Lockyer et al.(1980) and the INSEAD studies (1984, 1986). Surveys are very effective in identifying broad based issues, where widespread phenomena are under consideration, (e.g. patterns of labour productivity, use of particular operations techniques etc.). The large number of sites that can be covered with such techniques enables statistical techniques to be used in weighing the influence of various factors. They thus are valuable for investigating the importance of various elements in a set of industries etc. Against these strengths needs to be set a loss of detail and context from the individual research sites. Case studies offered greater scope for detail, which was of value in theory formulation. These benefits, however, were likely to be at the cost of fewer sites, as the time taken to collect case data is longer than that for surveys. Cases, however, offer a rich source of information, in which the interconnections between the different aspects of control within a company can be more clearly understood. They also afford a basis for theory formulation, Kaplan (1984c). He

argued that observations and descriptions using case studies are a major and important starting point for managerial research. He contended that they represent a suitable building block for initial classification, measurement, theory building and testing the generality and limits of any theory.

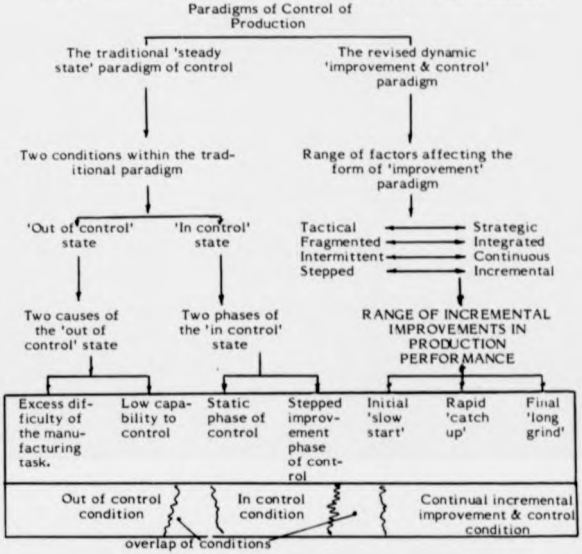
One of the dominant characteristics of managing production is the complexity of the production system. It is therefore critical that both the control systems and any research processes used to examine them are capable of reflecting this complexity. Case studies facilitate detailed observation and description of complex phenomena, which can be considered in the specific contexts. They enable the collection of data from multiple sources within a site, as distinct from data from more sites, but almost inevitably less widespread within each site. Given the aim of the research was the development of a framework of the different approaches to control, the case method was selected for the richness of the data that could be obtained and the relationships it could reveal.

3.2 THE OBJECTIVES OF THE RESEARCH

The central objective of the research was to develop a framework enabling corporate and production management to recognize the variety of paradigms of the managerial control of production. One aim of the framework was to facilitate understanding about the path of progression from the 'out of control' condition to the higher level condition of control and eventually to the 'continuous incremental improvement and control' state. A second aim was to identify the factors influencing the adoption of a particular paradigm of control within a company and thus by understanding this relationship enable management to improve their decisions.

A schematic representation of the traditional and revised paradigms of control and the key factors influencing their adoption are shown below in Figure 1.

Figure 1 The Framework of the Paradigms for the Control of Production



Advancing forms of the paradigm of control in production

Figure 1 shows the development from the 'out of control' condition to the revised 'control and improvement' condition. This sequence, however, is unsuitable for the presentation of the thesis, as it implies that firms move sequentially through these three stages to achieve progressively higher levels of control. Instead, I start my analysis with an examination of the traditional paradigm when it results in a state of control. I next show how the traditional paradigm can lead to the loss of control when it fails to adequately match the dynamic pressures of the competitive market. I then propose the revised paradigm which brings together control and improvement into an integrated activity for production management and workforce.

The seven case studies were unevenly distributed between the three conditions outlined in Figure 1 above. Six of the cases fell into the traditional paradigm, while only one, and that in part, adopted the revised paradigm. Of the six traditionally orientated cases, two were clearly in the 'out of control' condition, with a further case being partly in this same state. Table 1 below sets out the state of control in the case studies and identifies the industries involved.

Table 1 A Summary of the States of Control in the Case Studies

TYPE OF CASE	STATE OF CONTROL
Brake Manufacturer	out of control
Kitchen Furniture Manufacturer	out of control
Clutch Manufacturer	partly out of control
Ceramic Manufacturer	in control
Pump Manufacturer	in control
Medical Products Manufacturer	in control
Food Processing Company	control and improvement

Although the paradigms of control, outlined above, tend in terms of concepts and systems to be discrete, in terms of performance they form a continuum. This continuum is likely to entail substantial overlap in the level of performance achieved. The research investigated the cases to identify the factors influencing the three sets of outcomes and to establish the factors that led to their adoption.

3.3 SAMPLE OF FIRMS - CHOICE OF INDUSTRIES AND SELECTION OF SITES

The adoption of a two stage research process, collecting data via case studies, determined a number of factors in the selection of the research sites.

It was anticipated above that the use of case studies would result in a rich, but complex, set of evidence. In order to constrain the resulting variety to practical limits, it was decided to restrict the first three cases to a single industry. The automotive components industry was chosen, both because of its location in the

West Midlands, and because it was clearly experiencing strong competition and was more likely to be concerned with its approach to the control of production. These cases involved one plant concerned primarily with original equipment components and two plants primarily making replacement parts. The subsequent cases were drawn from a wide variety of industries covering: kitchen furniture, ceramics, food processing, and medical products. This was in order to test the paradigm more extensively under a wide variety of different conditions. In addition, by using a number of cases in a variety of industries, the existence of different paradigms was considered more likely to be revealed.

To reduce the large number of factors that could affect the findings, it was decided to examine only plants that met the criteria set out below:

(a) Between 200 and 5000 full-time or full-time equivalent employees.

(b) Not less than 30% of its employees engaged in either direct or indirect manufacturing tasks.

(c) Not less than 60% of the plant turnover from involvement in the selected industry.

The sites were selected by initially identifying companies, that appeared to meet the above criteria, from the 'Kompass' publication. This gave the nominal number of employees, a code indicating the general nature of their products and the name of their chief executive.

In each of the stages initial letters were sent to chief executives outlining the nature of the research and requesting a meeting with them to discuss possible cooperation in the project. 25 letters were sent in the first stage and 72 letters in the second. Replies were received from 42 companies, of which 18 agreed to an initial interview. Of these, ten agreed to support the research. Initial investigations were made in these cases. However, in three situations it was found that the evidence available was too similar to data from other cases to make further investigation necessary. One of these 'abandoned' cases was in the

automotive components industry. It followed the traditional paradigm, which led to the 'out of control' condition to the extent that data collection was very difficult, as very few records were maintained. Of the other two 'abandoned' cases, one was in the material processing industry. Its system of managing was such that the only identifiable 'production management' activity was control of its small direct labour force. As its approach to control most closely approximated to the step phase of the traditional paradigm, which was well represented in the other cases, it was decided not to pursue the investigation at this plant any further. The remaining case, an engineering firm, was another example of the step phase. After the commencement of the research a change in the managing directorship led to a loss of cooperation and the eventual abandonment of the research site.

It was recognized that the above methodology, using seven case studies, inevitably placed a restriction on the extent that the fieldwork can be used in making statements about the overall population of British manufacturing industry. Yet, the problems revealed were far from unique to any one industry. Accepting the limitations of coverage, inevitable in a Doctoral submission, it is hoped that this research will stimulate other researchers into examining the applicability of its findings in other parts of U.K. manufacturing.

3.4 HOW THE RESEARCH WAS CONDUCTED

Semi-structured interviews were held with the managing directors and all senior functional heads of departments to establish how the companies attempted to compete. Samples were collected of all non accounting and selective costing written control reports received by the managing directors and production management. These were examined and the recipients interviewed to ascertain how, if at all, they were used in the process of controlling production. Based on an analysis of these reports and the managers' descriptions of their use of the

reports, I classified each report on a five point scale, in terms of its ability to contribute to the managerially identified KMTs. I developed a system for evaluating the customer service and resource efficiency dimensions of performance and linking them with the KMTs in the respective plants. I also devised a complementary scoring system which evaluated the individual reports in terms of their contribution to the recipients' identification of good and poor performance. The interviews with production management and supervision established any other means they used to obtain information to help control production. This was reinforced by the use of questionnaires which established the managers' preferred sources of information, their educational background and any training they had received in production management. Interviews were then held with all levels of production management to ascertain their approach to controlling production and to establish whether they considered they had any specific role in bringing about improved performance. If they did consider that they had such a role, the particular form that it took and the means they used in attempting to accomplish it, were identified.

The heads of the main staff functions, providing information to general and production management, were also interviewed to establish the roles played by the functions in the control of production.

The contents of the control reports were compared with the competitive goals. The performance of production in customer service and resource efficiency was evaluated using a series of scales reflecting firstly the importance of the dimension of performance and secondly the value of the report in controlling performance. Scales were also developed for 'improvement'. These classified the levels of strategy, integration, continuity and incrementalism of the plant. Investigations were undertaken to establish whether production performance could have been improved by the exercise of more effective means of control; for example in the level of quality achieved or delivery accomplished.

Details of the research process are provided in Appendix A.

4. THE 'IN CONTROL' CONDITION OF THE TRADITIONAL PARADIGM OF CONTROL IN PRODUCTION

4.1 THE 'IN CONTROL' STATE IN PRODUCTION

The literature review showed the nature of the traditional paradigm of control proposed for senior and production management. The perspective was, in the main, that of regulation within prevailing conditions rather than creating conditions which were more likely to lead to a state of control. In essence the model reflected a reactive rather than proactive approach on the part of the production management team. The development of manufacturing strategy has offered scope for a more proactive approach to the control of production, via reductions in the complexity of the manufacturing task and the creation of the pre-conditions needed for an effective state of control.

In sections 4 & 5 I examine the way in which six plants, all of which followed the traditional paradigm, practised control of and over their production functions. Although all followed the traditional paradigm, albeit in differing forms, their performances differed significantly. For the sake of a clearer analysis, I divide my presentation of evidence into two sections, the first concerned with instances where the plant was in a state of control, the second where it was not. It is important to recognize, as shown in Figure 1, that both the 'in' and 'out of control' conditions can arise from adopting the traditional paradigm of control. Although, for the sake of exposition I separate my reporting of these conditions, they need to be considered as opposing ends of a continuum, with the case studies spaced along it. Classification of a plant as 'in', or 'out of', control was for some a matter of degree rather than of an absolute state.

This section is concerned with plants that had achieved a state of control at the time of the fieldwork, while following the traditional paradigm. This represents the basic model which literature on the traditional paradigm promotes as the solution to the needs of manufacturing plants.

Proposition
The traditional paradigm is composed of two alternating phases: long

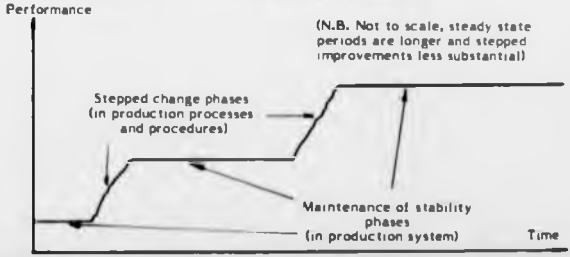
periods of stability, interspersed with short periods of 'stepped' changes when production performance is raised to meet new requirements in the market. When competition is intense, larger and / or more frequent steps are taken to meet the market's requirements. Even while maintaining a state of control, the absence of a strategy for production can lead to the step changes being inconsistent with each other and the market. This may lead to the manufacturing task becoming very difficult to control.

The four 'in control' cases covered a wide range of the condition. At one end of the scale was a plant producing automotive clutches. The majority of the plant was in a state of control; however, because its assembly department was 'out of control', its overall performance was unsatisfactory. At the other end of the scale was a plant producing medical products, where production was well under control following a recent set of stepped improvements.

4.11 Defining the Phases of the 'In Control' Condition

Section 2 showed that much of the literature reflecting the traditional paradigm is concerned with maintenance of the 'static state' phase of production performance. The paradigm predicates that the production system remains for long periods in the 'in control' phase. During this phase production management's role in the process of control is typically accomplishing cost and output goals. While in this phase, the production system must be able to withstand the natural range of variations and disturbances associated with its particular industry. This emphasis can lead to inadequate recognition of the linkages between the two phases. This linkage is shown below in Figure 2.

Figure 2 The Traditional Paradigm of Control in Production



The balance between the two phases is most clear in respect of technological innovation, particularly when this involves major capital expenditure. However, a more subtle form of separation exists during the so called 'long run' or 'steady state' phase. This is the separation between the usually smaller step improvements to the processes / procedures brought about by staff functions. Production management's role in these steps is predominantly as adopter, rather than as leader of the innovations.

The number and significance of these intermediate level steps varies significantly between firms adopting essentially the same 'traditional' paradigm. This reflects the continuum between the 'out of control' and 'continuous improvement' conditions. Plants near the 'continuous improvement' condition made a number of these smaller steps, while those at the lower end of the continuum generally made less. This latter state of affairs varies considerably between those plants which make determined efforts to escape from the near 'out of control' condition and those that slide gently into a loss of control. I retain the term 'steady state' for plants where such improvements occur, for two reasons. The first is because the production managers still follow the traditional perspective of maintaining stability, leaving the leadership of change in the hands of staff functions. The second reason is to help distinguish between these 'intermediate' stepped improvements and the continuous improvement found in the revised paradigm.

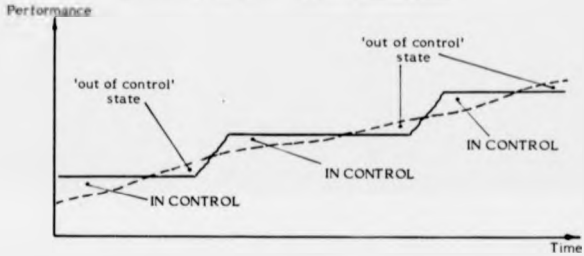
4.12 The Limitations of the Traditional 'Steady State of Control' Paradigm

Three weaknesses can be identified in the traditional steady state paradigm, which can lead to movement from the 'in' to 'out of' control condition. The first is the maintenance by production management of 'stability' when continually higher performance is required. The second is the use of step changes to restore competitiveness which can also lead to mis-matches between products and processes which result in the manufacturing task becoming too difficult to

control. The third is when production management's attention is focused on artificially restricted sub-sets of performance criteria, rather than on the full range of ways in which production needs to support competitiveness.

Figure 3 below demonstrates the relationship between the required and actual levels of performance and how a deterioration in this relationship can lead to the 'out of control' condition.

Figure 3 An Illustration of the Comparison between 'Stable' Production Performance and Adaptive Market Requirements



N.B. The extent to which the 'out of control' condition occurs is a function of the relative positions of the 'actual' and 'required' levels of performance.

Actual Performance ———— Required Performance = — — — — —

Production can cease to be in a state of control during either the 'stability' or the 'stepped' phase. In the stability phase, the loss of control is likely to arise from failure to react to changing requirements and / or only regulating limited aspects of performance. In the stepped change phase, errors in the design of the system can lead to unnecessarily complex tasks or tasks which are not well linked with the way in which the firm intends to compete.

4.2 THE IMPACT OF, AND RESPONSE TO, COMPETITION IN THE CASE STUDIES

Proposition
The traditional paradigm of control leads to firms making step changes to their manufacturing systems and processes to meet growing competitive pressures. In the absence of manufacturing strategies a number of these changes will lead to unintended increases in the difficulty of the manufacturing task.

The plants in the 'in control' cases were examined to identify competitive pressures they experienced and how they adapted their manufacturing systems / processes to respond to these challenges. I also identified whether they possessed manufacturing strategies to guide their design of the manufacturing system.

4.21 Competitive Pressures in the 'In Control' Case Studies

Interviews with senior management in the various 'in control' case studies revealed competitive pressures faced in these plants. The individual pressures are identified below.

In the clutch case, the Manufacturing Director and Marketing Manager both stated that their plant faced strong competition from other producers. The Manufacturing Director said,

> "We are in for a hell of a fight (for survival) over the next two years unless demand outstrips supply and we can raise our prices. ...we really ought not to be able to survive, we can only do so because we are quick on our feet. If our competitors knew what we were planning to do, we would be finished."

Interviews with the Manufacturing Director and Marketing Manager showed that they considered that the firm's strongest challenges were to its product quality and manufacturing costs.

In the medical products case the plant had been taken over three years earlier, after it had nearly ceased trading. The Managing Director reported that, at that

time, over half the product range was not recovering its full costs and the plant as a whole was losing money.

The plant in the automotive pump case started off in a stronger competitive position than the other 'in control' cases. However, its senior management identified that it too faced competition, mainly from overseas producers, offering low priced alternatives.

Competition in the ceramics case was from two sources, with sophisticated producers in Europe making high added value products and third world countries making simple, low added value products.

4.22 The Absence of Strategic Frameworks to Direct Manufacturing Management

I discussed above the use of manufacturing strategies to constrain the complexity of the manufacturing task and as a basis for a more proactive approach to the control of production. Two strands of argument were evident in this approach; focusing and product / process analysis. In Western plants the main form of 'focus' is a narrowing of the product range, while for the Japanese the emphasis has been at a micro level focus, looking at generic processes and operations. The focus approach reduces the complexity of the task and thus eases the costs associated with its control. Process / profile analysis provided the basis for coherence between the manufacturing infra and technostructures and in the way the plant competed in the market place. Neither of these approaches is part of the traditional paradigm. However, as their presence would have affected the approach to control, I identified whether they were or were not used in any of the cases.

I established in interviews with the Managing Directors and Senior Production Managers that in none of the case studies did management have a written strategy

for manufacturing. In the clutch and pump cases the Managing Directors responsible for the plants confirmed that they were unfamiliar with the concept of manufacturing strategy. The timing of these investigations in 1981-2, could partly account for this lack of knowledge about manufacturing strategy. In the medical products case, where the data was collected in 1983-6, the Manufacturing Director was actively seeking to establish such a strategy. However, in the ceramics case, where the data was collected at the same time, there were no attempts to form a manufacturing strategy.

4.23 The Difficulty of the Manufacturing Task & Controllability of Production

Proposition
When manufacturing faces strong pressure to compete, yet lacks a strategy to guide its techno and infrastructural design, the manufacturing task is likely to become over complex and difficult to control.

The difficulty of the manufacturing task differed between the cases; it was strongest in the clutch case and least in the medical products case.

In the clutch case the difficulty of the manufacturing task grew as a result of a number of corporate level decisions; expansion of the 'aftermarket' product range, entry into the original equipment market and a major improvement in quality.

The entry into the 'original equipment' product sector, combined with the planned expansion of the replacement parts market, led to a serious conflict in terms of product design and type of manufacturing facilities required. The original equipment target was 10-15% of current output. This was sought via contracts with a major vehicle assembler for two clutches, based on some of the plant's current top 10 best selling lines as the basic design. Replacement parts were expected to grow by 50% over two years, in selected outlets. The Marketing Manager, but no one else, discussed increasing the sales of commercial vehicle clutches from 3% to 15% of plant volumes. Based on company data for average monthly sales, I calculated the figures shown in Table 2 below.

Table 2 Estimated Changes in Monthly Demand for the Top and Bottom 10 Types of Clutch in the Product Ranges

PRODUCT TYPE (CLUTCH)	REPLACE-MENT CURRENT (a)	REPLACE-MENT EXPECTED (b)	Orig.Equip. DEMAND (c)	TOTAL DEMAND (b) + (c)
(Plates) Top 10 items	1,000 7,000	1,500 10,500	6,500	1,500 17,000
Bottom 10 items	3-24	5-36	nil	5-36
Maximum increase in output of top 10 items 243%				
(Covers) Top 10 items	900 4,000	1,350 6,000	6,500	1,350 12,500
Bottom 10 items	1-20	2-30	nil	2-30
Maximum increase in output of top 10 items 313%.				

N.B. (b) = (a) plus the planned 50% increase in demand.

The values in the table show the largest and smallest demand per month in each of the top and bottom selling lines.

The assumption of an across the board increase in sales for replacement parts was unlikely. I established via the Marketing Manager that the marketing channels selected for expansion all concentrated on high volume product lines. He subsequently agreed that this was likely to lead to a proportionally greater increase in demand for the high volume 'aftermarket' lines. This change in emphasis in product mix was additional to that in Table 2 above. He confirmed that he had not discussed the implications of such a shift with anyone from the plant, arguing that, in his view, there was no change, as all the items were currently being produced and therefore production did not need to do anything it was not currently doing. Thus, the implications for production of changes in the product mix were not signalled to the plant. Yet, at least two important implications existed. Firstly, the emphasis on higher volumes increased the importance of cost performance as these products competed directly with those of the much larger original equipment producers. Secondly, the shift in volumes combined with a different balance in the 'order winning criteria' was leading to a product / process mis-match.

Additionally the current product designs were based on achieving economies in tooling costs through using a two piece design, which enabled common components to be used in a number of end products. The Chief Designer confirmed that this configuration was more expensive for high volume products but, with the current product mix, gave a lower overall cost. Retaining this strategy for original equipment products would make them more expensive than those of their main competitors. If a new one-piece design were introduced for high volume lines, as well as for original equipment products, the volume in the remaining product lines would be too small to achieve acceptable cost levels.

In order to highlight a further dimension of the conflict, a comparison of the competitive factors influencing sales of original equipment and replacement parts was undertaken in conjunction with the Marketing Manager. The results are shown below in Table 3.

Table 3 Rank Order Comparison of Factors Affecting Sales

ORIGINAL EQUIPMENT		REPLACEMENT PARTS	
Quality Reliable delivery Price	}	Must meet minimum specifications	Price Delivery service (speed) Range Availability Ease of ordering Quality of product Presentation of product

The main variable in winning orders in the original equipment market is price, with quality and reliability of supply acting as an order qualifying criterion. In the replacement market many items could affect winning an order, but the largest single issue remained price.

In the other 'in control' case studies, the impact of decisions taken outside manufacturing had significantly less impact on the complexity of their manufacturing tasks. The pump case faced similar conflicts between a planned increase in

original equipment sales and replacement parts. However, as the plant had a much larger penetration of the replacement market, its volumes were generally higher and thus less sharply in conflict with those of the original equipment market. The conflict in market criteria remained. Thus the balance in KMTs, in terms of rapid response versus low cost, was adversely affected. In the medical products case the product range had been initially pruned to remove unprofitable lines. The new products replacing unprofitable lines were largely consistent with remaining 'older' product lines. In the ceramics case there was a movement towards more 'specials' and away from standard products, which added to the complexity and uncertainty.

The above evidence, particularly from the clutch case, supports the view that seeking to respond to competitive pressures without the guidance of a manufacturing strategy can lead to a growth in the complexity of the manufacturing task, making control of production more difficult to accomplish. Thus on occasions, this may lead to achieving less than the expected benefits and / or a worsening of the mis-match between the manufacturing task and manufacturing process / procedure. The significance of process mis-match can be heightened by the central role of production in corporate competitiveness. This is demonstrated by the growing importance attached to achieving both higher quality and lower priced products, similarly in achieving high flexibility and low inventory levels. Where these joint goals are sought as separate entities, there are likely to be serious instances of mis-match in the processes and systems used to seek their attainment. The importance of manufacturing strategy and the achievements of the Japanese approach to manufacturing provide examples of where these 'manufacturing based' achievements have been accomplished.

4.24 The Use of Stepped Changes to Restore Competitive Performance

Proposition
To meet increasing competitive pressures, management implements step changes to the manufacturing system. Although many of these increase competitiveness, others, in the absence of a manufacturing strategy, lead to a loss of control as a consequence of the process mis-match phenomenon.

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Table 4 The Main Forms of 'Stepped Change' in the 'Steady State' Cases

Case Studies	Nature of Stepped Improvements			
	Re-design product range	Re-layout plant	Investment in prodn. processes	Investment in systems/ procedure
Ceramics	Minor	Medium	Medium	Medium
Clutches	Major	Minor	Minor	Major
Medical	Major	Medium	Minor	Minor
Pumps	Minor	Minor	Medium	Major

4.241 Improvement via redesign of products

I noted in section 2 that a typical 'Western' response to competition was to increase the product range, even at the cost of increasing manufacturing complexity.

The clutch case Manufacturing Director reported the Board's decision to strengthen the plant's in-house design capability, in order to widen its product range and improve product quality. These moves were expected to lead to a substantial increase in sales.

In the medical case, the takeover was followed by a major emphasis on redesigning the product range to improve the 'attractiveness' of products and reduce their costs. The total range was cut by approximately one third. Of the remaining range over 50% of the products were new or redesigned. This was followed by a re-modelling of the production system to reduce costs of assembly. The company planned to maintain its new found profitability by sustained product innovation, with the declared goal of one third of its product range being less than 2 years old.

The production literature generally recognizes the link between product design and complexity of manufacturing. Two case studies involved major redesign of product ranges; clutches and medical products. In both of these the management reported that the redesign exercise was intended to serve the dual

purpose of making products more attractive and reducing the costs of manufacture. The cost savings were only discussed in terms of production and tooling costs. No reference was made to the impact on the administrative systems and therefore on overhead costs.

In the pumps case the redesign exercise was comparatively minor in terms of the number of items affected, but the potential impact was large in that it was intended to achieve economies of scale by increasing the degree of standardization of the most expensive components. The clutch case involved similar attempts to cut production costs as well as improve product performance through better designed, lower cost components.

4.242 Improvement via re-layout of plant

In all four 'steady state' cases work study / industrial engineering departments were used to redesign the layout of substantial parts of the plants in attempts to raise performance and improve the control of production. In the clutch case study the main re-layout occurred in the assembly department. Unlike the changes to the product designs, the re-layout of the plant was intended, in conjunction with the limited use of some new machinery and inspection equipment, to reduce the complexity of manufacturing as well as to help raise the quality of the assembled clutches.

In the pumps case an experimental group technology cell was developed to machine bodies for a selected range of pumps. The Industrial Engineers redesigned the system from a traditional 'batch' layout to a cell reducing the handling of the products and speeding up throughput times. In the medical case the assembly lines were redesigned, reducing them from long chains with 15-20 operatives, to a mixture of small teams of 5-6 operatives and, in some instances, single operatives. In both case studies the redesign of the plant layout assisted

manufacturing by reducing the complexity of the workflow. However, even after detailed questioning of the Industrial Engineers and Production Managers involved, I was unable to be certain that these gains were intended or whether the exercises were based on achieving the simpler goals of reduced lead times.

4.243 Improvement via investment in production processes

Investments in the production processes in the clutch case were limited to investment in one dedicated machining centre. However, it was intended to expand the proportion of the product made 'in house', by producing some of its own components. This was expected to lead to major investment in new processes. The pumps case involved investment in one major new machining centre and the replacement of several traditional lathes with CNC lathes. In the medical case the major expenditure was the purchase of a new sterilization unit and small scale changes to the flow lines. The ensuing discussions with Industrial Engineering and the Accountants revealed that these investments were made on the premise of savings in costs in manufacturing and that reductions in complexity had not been advanced as a reason for them.

4.244 Improvement via investment in systems and procedures

Both the clutch and pumps cases spent approximately £250,000 on new MRP II production control systems. The quality control systems in both cases were also improved. In the clutch case this led to the expenditure of a further £250,000 on inspection and testing equipment. In the medical case the emphasis was on work measurement of the entire plant using a predetermined motion time system (PMT). The changes in the supplier quality assurance (SQA) systems were demanded by the original equipment product customers. The change in the work measurement system was triggered by the inconsistencies in earnings and the lack of adequate data for planning.

4.243 Benefits and limitations of stepped improvements

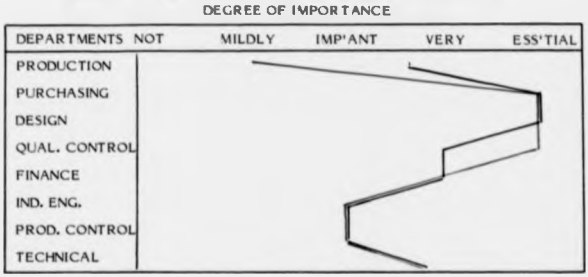
It can be seen from the above examples that in all 'in control' cases efforts were undertaken to adjust the production system, both at a technological level and in terms of systems and procedures. As has been identified above, these changes are necessary to maintain a state of control in a changing set of environments.

It will have been noted, however, that the step changes identified above were all based on staff initiatives. Production management's role was that of implementor, rather than innovator. Further, it was evident from extensive discussions with line and functional staff that there was no systematic plan to reduce the complexity of the manufacturing process in order to achieve more effective control of performance.

4.3 SENIOR MANAGERS' USE OF LINE AND STAFF IN THE CONTROL OF PERFORMANCE

The following section examines the senior plant managers' use of line and staff managers in controlling production performance. The clutch case Managing Director exhibited the strongest inclination to use staff rather than line for the control of production. This pattern is shown below in Figure 4.

Figure 4 The Managing Director of the Clutch Case's Expectation of Contributions to Competitiveness from all Plant Functions.



N.B. ——— current contribution ——— expected contribution

Production was expected to make the smallest contribution to corporate competitiveness of all functions, both currently and in the future. The Managing Director was unable to place the expected contribution on the five point scales provided. He classified production as 3.5 on the scale. (This was recorded as such, rather than attempting to constrain his choices into the classification system.) The significant points about production that emerged from the subsequent discussion were:

(a) it had the lowest rating of all functions, in its perceived contribution to current competitiveness.

(b) it required the largest increase in raising its contribution to competitiveness over the next five years (2 to 3.5).

(c) even with the achievement of the new competitive levels, it was still expected that production would be slightly less important as a competitive function than the plant average for all functions.

Analysis of the current and expected contributions anticipated from the different departments suggests that the Managing Director placed more importance on the 'office' based functions than on those close to production.

4.31 Comparing the Expected Departmental Contributions and the Markets' Requirements.

The rankings of departmental contribution to competitiveness in the clutch case, as shown in Figure 4 above, were compared with the tasks the Managing Director had identified to be performed by the individual functions. The results of this comparison are shown in Figure 5.

Figure 5 A Comparison of the Managing Director's Ratings of Departmental Contributions to Competitiveness and their Key Tasks

DEPARTMENT	CURRENT RATING	FUTURE RATING	REDUCE PLANT COSTS IN PURCHASES (63%)	OVERHEADS (33%)	IMPROVE DIRECT LABOUR (4%)
PRODUCTION	2	3.5			Reduce production indirects Reduce W.I.P. via shorter lead times. Make greater proportion of components 'in - house'.
PURCHASING	5	4	Close monitoring of prices. Value analysis team.		
DESIGN	5	5	Make v. Buy decisions. Value analysis.		
QUALITY CONTROL	5	4			
FINANCE	4	4	Monitoring costs	Reduce variety based costs Reduce fixed elements of costs. Monitor all costs.	Measure return on investment Examine cost implications of product quality.
INDUSTRIAL ENGINEERING	3	3	Develop value analysis and engineering. Make v. Buy decisions.		Main task - reduce direct labour content. Improve plant utilization. Develop 'process layouts' for cost reductions.
PRODUCTION CONTROL	3	3		Reduce overheads by restricting variety of items made per month. (G.M.'s initiative, not PPC's.)	Reduce stock levels / W.I.P.
TECHNICAL	4	4		Reduce tooling costs	

It will be noted that the principal theme for all functions was cost reduction, followed in selected departments, by a widening of the product range and improvement to product quality. Even these goals were adopted in order to reduce unit costs, by increasing the level of activity. The Managing Director explicitly declared that he did not expect the plant to gain significant cost reductions from experience curve effects.

The emphasis on cost control shown above highlighted the omission of attention to other key aspects of performance. Control of 'delivery' was split between the plant and stock planning. Stock planning was responsible for determining the ordering of products on the plants and the level of finished stocks. They placed so-called firm orders on the plant for the next three months and tentative orders for three further months. Despite these 'firm' orders, stock planning was able to operate a 'back-order' system which took precedence over all firm orders. This included the 'right' to first use of any machinery and of any material, even if this material had been set aside for a 'firm' scheduled order. Firm orders could also be cancelled by stock planning even if manufacturing had commenced.

The back-order situation in the clutch plant was serious but had shown significant improvement. Back-orders for manufactured items had declined in the previous three months from £143,000 to £53,000. Analysis of back-orders revealed that for items over £1,000, the average time in arrears was 4.5 weeks. Orders for factored items in back-order had declined from £82,000 to £72,000. Despite these significant levels of failure to meet the customers' orders, there was no examination of the means of achieving delivery performance. The only effort to overcome this problem, that could be detected, was pressure by the Managing Director on the Assembly Superintendent to improve his section's output and to monitor the output of selected machines in the machine shop.

It was seen above that the manufacturing functions placed their emphasis on

the control of cost performance. Although an important factor in the company's survival, it was only one element of competitiveness. Not only did the management of the clutch case lack a strategy for its manufacturing function, which might have enabled it to compete more fully via manufacturing, it also failed to exploit the other dimensions of competitiveness identified earlier by the Managing Director. Thus it can be seen that staff were perceived to be the control vehicle through which competitiveness was to be accomplished. It is also evident that despite statements by the Managing Director and the Marketing Manager, the critical issue, as far as actual attention was concerned, was cost control.

4.32 Staff Based Control of Production

Evidence of a bias towards staff based control was found in the pump and clutch cases. In both cases it was decided at corporate level to revise the production control systems to the more sophisticated MRP based systems. In the pump case the system was run by a production control function which reported directly to the plant Managing Director. In the clutch case, however, the shift to staff control, was countered by a reorganization of the structure so that the Production Controller reported directly to the Production Manager. The Managing Director advised me that he made the change...

> "...in order to reduce the Production Manager's excuses for failing to meet the planned level of output and to reduce the level of work-in-progress".

Under the new structure the Production Manager was intended to exert greater influence on the work load of the plant.

However, the impact on production of the system of production control in the two plants was different, as a result of moves in the pump case to make greater use of small flowlines, CNC cells and machining centres. These technical changes resulted in a growing part of the work of the production control system being devoted to loading the front end of cells, rather than detailed processing of

work between individual machines. The impact of these individually small changes in the roles of production managers and functional staff tended to steadily shift the organisations into a position where the real power to control lay in the hands of the staff. The line managers still carried the formal responsibility for what was achieved but lacked the capability to determine what solutions were sought. Such a situation is bound to lead to conflict. It is unlikely that such conflict will lead to a constructive dialogue and thus better control.

4.33 The Approach Staff Used in Seeking Control over Production Performance.

I have shown above that the Managing Director in the clutch case relied primarily on the staff functions to control the plant. This was demonstrated particularly clearly in the ways in which the step changes, discussed above, were achieved. As I showed above, the way in which 'staff' in the four control cases carried out this control was not based on reducing the uncertainty / complexity in the manufacturing system. Instead they tended to seek to overcome the complexity of the manufacturing task by building powerful means of controlling (control systems).

The industrial engineering / production engineering functions in the four 'in control' cases were primarily responsible for the selection of plant and machinery, as well as for the layout in the plants. This role was reinforced by the systems for capital expenditure approval used. The submission of detailed 'project proposals' required full costing figures which could currently only be achieved via industrial engineering. This became formalised with the industrial engineering department becoming the authorised function for project proposals.

Production management in the pump and clutch cases had previously been responsible for the selection and layout of plant. Both retained a role in the layout of the plant, but the responsibility for producing the plans, carrying out

the changeovers etc. was officially that of the staff groups.

A number of other manufacturing decisions were examined to establish their impact on the level of complexity and uncertainty of the manufacturing task.

The importance of creating a simple, non-complex solution with low inherent uncertainty was recognized in terms of the functional performance of product design in all case studies. This logic was not, however, applied to the manufacture of the products. The strategy in the medical case was based on achieving superior performance through simple designs, which were attractive in the market and economical to produce. In the pump case a major programme of component standardization and product improvement was based on analysis of the warranty claims. The Managing Director confirmed that seeking improvements in product design was an essential component of his approach to controlling the plant.

Reductions in the complexity / uncertainty of the manufacturing processes and procedures were detected in some of the improvements. These improvements were examined and the managers responsible for them interviewed in order to identify the thinking behind their application. A word of caution is, however, necessary. The following improvements give an unrepresentative impression, in that they reflect the few major changes made to the system over extended periods.

The industrial engineering function in the pump case was the most innovative function in the 'in control' cases, in terms of seeking to reduce complexity. They simplified the manufacturing process by moving, in a few trial areas, from conventional machining and assembly to two small cell systems. Machining operations were cut from seven to three stages, using multi-functional tooling. The conventional benefits of reduced lead time and rejection levels were accomplished. The paperwork system used to control the flow of production was reduced to a

seventh, without any attempts being made to reduce the number of carbon copies sent to the various departments, (i.e. accounts, stores, PPC etc.).

The plant in the medical case was working on similar lines to reduce the complexity of its assembly operations. This involved changing from long 'assembly lines' which had entailed up to 20 workers to a combination of single work stations and small groups of 2-3 workers per product.

Assembly in the clutch case was reorganised reducing the seven mini lines to three flow lines, which exploited the commonality in the assembly of most of the products.

While these programmes of reducing uncertainty / complexity were important in the plants, it is necessary to recognize that they were phases or programmes which were being undertaken at the time of the research. I interviewed all the heads of the staff functions in these cases seeking to identify whether they had approached these problems with any particular philosophy or conceptual framework to guide their activities. Almost universally their initial responses were in terms of the closer monitoring of production performance, rather than changing the way in which the system worked. These responses appeared to me to conflict with the actions set out above. When probed about the nature of the solutions adopted, the heads of the functional departments defended the techniques or approaches as isolated events. I concluded that they did not have any explicit philosophical approach towards these issues, aimed at the reduction of complexity. The gap between their initially expressed views and the practices in some staff departments raised the possibility that they tend to articulate the textbook answer, but intuitively sought to accomplish solutions which are closer to the revised paradigm of control in production.

The major exception to this view was the Chief Industrial Engineer in the

clutch case. He emphasised control over, rather than control via, the process view when he declared that,

> "Production management just want to be everyone's friend. We (industrial engineering) have to come in as the police force."

This type of view was consistently rejected in the pump case. There, both the Chief Industrial Engineer and the Quality Manager identified the design of the production process as critical to the control of performance. The unusual forthrightness of their view made their perceptions noticeable. I concluded that some of the heads of staff functions in the 'in control' cases were intuitively aware of the means of achieving better control in, and of, production, via reducing the uncertainty / complexity. However, they only adopted these approaches in a relatively few instances. The majority of times they relied on the traditional paradigm standard approach of increasing the sophistication of the mechanisms of control.

4.4 SENIOR MANAGEMENT'S CONTROL DURING THE 'STEADY STATE' PHASE

I showed above how the form and level of competition found in the 'in control' plants was identified. I also showed that they did not possess manufacturing strategies which linked their marketing and production systems into coherent controllable wholes. Additionally, I dealt with how the Managing Directors assigned the roles between their line and staff functions for the two phases of the traditional paradigm.

In turning to the maintenance of control during the so called steady state phase, it must be recognized that the level of difficulty experienced in the control of production is significantly affected by the nature of the preceding stepped changes. Two factors have been shown to be particularly important. The first is the extent to which changes introduced in the step phase are consistent with the corporate strategy and the second the extent these changes affect

the complexity of the manufacturing task. Neither of these problems can be adequately overcome in the steady state phase, as both require resolution prior to it. However, the monitoring system, (as distinct from control), can be designed to detect the occurrence of such difficulties.

I now examine the way in which the Managing Directors controlled production during the critical 'long run' stage in which production's key role is traditionally perceived to be the maintenance of stability.

4.41 Attempts to Control the Complexity of the Manufacturing Task

Proposition
The strategy of control and the reports received by senior managers do not reflect the complexity of the manufacturing tasks demanded of production. They are particularly ineffective in dealing with internal as distinct from external complexity.

I showed above, in sections 4.24 to 4.242, that the manufacturing task in the automotive component cases had grown significantly more complex, as management sought to improve the companies' competitiveness. This also occurred, to a lesser extent, in the medical products case. However, in the latter, the effects of increased complexity were mitigated by the simplification of the product range.

4.411 Approaches towards reduction of complexity in the manufacturing task.

In the clutch and pump cases I found two sets of actions which countered the effects of the growing complexity of the manufacturing task. Firstly, was an increase in the degree of component standardisation. (As I have discussed this earlier in the step phase I do not propose to deal with it again here.) Secondly, the Managing Directors sought to restrict the variety of products produced per month. Neither action was intended to make the manufacturing task easier, but was made in order to reduce costs. Yet to achieve this goal both of these actions had to restrict variety, and thus complexity, within the system. These actions

accorded with the 'law of requisite variety', in that the restrictions limited the variety that needed to be controlled as an alternative to increasing the control capability of the regulating system. Both Managing Directors were interviewed to ascertain why they adopted these approaches. They each confirmed that they were unaware of the 'law of requisite variety' or the concept of 'focused manufacturing'. The Managing Director of the clutch case, a graduate engineer, did, however, recognize the principle when it was subsequently explained. I therefore concluded that both of them adopted the responses of variety reduction from empirical rather than theoretical bases.

The control reports received by the Managing Directors, in the clutch and pump cases, helped them restrict the complexity of the manufacturing task by limiting the range of items scheduled per month by systematically monitoring the orders placed on their plant. An example of the report used in the pump case is shown below as Figure 6.

Figure 6 Reporting Scheduled Range of Products per Month in the Pump Case

Product Group	Total in Range	Arrears %		Period Numbers 7		8		9	
A	32	8	(25)	7	(22)	7	(22)	11	(34)
B	382	29	(8)	48	(13)	82	(21)	81	(21)
C	219	11	(5)	35	(16)	45	(21)	32	(15)

The figures in brackets show the percentage of the range scheduled per month.

As the approach above ran counter to the practices emerging from Japanese industry, I investigated the topic in greater depth. The Managing Director in the clutch case claimed that as a consequence of his interest in restricting the variety scheduled, the Plant Accountant had undertaken a special investigation which showed that plant costs could be reduced by 10%. I subsequently inter-

viewed the Accountant who stated that his estimate was based on '... very broad brush' figures. He said that if the variety were restricted to only 25% of the current monthly variety, it could save between 1 and 8% of the works costs. Of this 2/3rds would come from changes in production methods, rather than from variety reduction itself. The reduction to 25% of current scheduled range would have meant that the drive plates were made once every 7.5 months and the drive covers once every 5.3 months. The result would have been large stocks at the finished goods warehouse. Yet, these company costs were not included in the estimate. A further criticism of the figures was that they did not make any allowance for savings in the overheads, through the reduction of staff, which would have been possible from the smaller number of orders to be transacted. Thus, the whole basis upon which this particular approach to uncertainty reduction was based, was built on a very inadequate level of analysis. The figures produced by the Accountant compare unfavourably with the estimate by Abegglen & Stalk (1986) that total costs could in general be reduced by 30%, as a consequence of a 75% reduction in range.

4.412 Inadequate control of 'internal' complexity.

I have shown that, however ineffectively and unintentionally, the Managing Directors in two of the cases took actions which had the effect of constraining the complexity of the manufacturing tasks in their plants. As discussed above this was done in order to control costs that arose as a consequence of the complexity of the manufacturing task.

As noted above, the approach adopted in these cases departed significantly from that advanced in both 'manufacturing strategy' and 'Japanese' based approaches to controlling manufacturing. These suggest that the control of uncertainty / complexity is accomplished by reducing the internal complexity of the manufacturing system. They seek to combine greater certainty within

production and low finished goods inventories. This combination is achieved by improving the quality produced, reducing setup times, making labour and machinery more reliable etc.

The goals of smaller inventories and higher quality were particularly important in the automotive component cases, as they were predominantly in the 'replacement parts' market. This market is characterised by wide product ranges with relatively low volumes. If the problem had been examined from the manufacturing strategy perspective and some of the Japanese orientated techniques such as small batch production and total quality control (TQC) adopted, both goals would have been achieved. These approaches would have, in turn, led to reductions in uncertainty and probably complexity in the manufacturing system.

I raised these alternative approaches with the Managing Directors in the clutch and pump cases. Both expressed considerable initial scepticism whether the necessary reductions in 'setup' times could be achieved. Doubt was also expressed whether quality levels could be improved sufficiently to enable small batch production to proceed without incurring penalties from 'occasional' batches with high levels of rejects. In a sense both areas of doubt reflected an awareness that the current systems of production incurred naturally high levels of 'internal' uncertainty. Management in both cases considered it easier and more effective to restrict the 'external' uncertainty, rather than resolve the 'internal' uncertainties.

I do not claim that the choice between internal versus external uncertainty reduction was anything other than an empirical one. However, the choice and its consequences were real, even if made without full awareness of its implications.

In the next section I examine the reports and exception studies the Managing Directors received and consider whether their content facilitated more effective

control of manufacturing performance.

4.42 The Routine Information Received by the Managing Directors

Copies of all the Managing Directors' non accounting reports were obtained and the proportions dealing with the major categories calculated. Based on a notional 20 day, 4 week month, the number of reports per month was identified. The results of this analysis are shown below as Table 5.

Table 5 The Proportion of the Reports Received by the Managing Directors on the Major Categories of Performance

Category of Performance	Case Studies			
	Clutch	Pump	Medical	Ceramic
Physical Quantities	31	38	28	73
Plant Utilization	15	14	-	-
Plant Load	14	12	1	3
Labour Performance	3	5	12	-
Stocks and W.I.P.	18	8	24	-
Quality	>1	3	6	3
Financial	5	4	3	7
Sales and Delivery	15	16	27	13
Total Percentage	100	100	100	100
Total Number of Reports	162	183	87	30

N.B. In addition to the reports shown above the Managing Directors received monthly written reports from the heads of the main functions in their plant.

The proportion of reports in the ceramics case reflected a daily report which the Managing Director said he only 'glanced at'. Two other factors had significant effects; his declared marketing orientation and an 'on-line' computer system. To counter his marketing (and financial) orientation, the Manufacturing Director received complementary reports on labour, quality, WIP etc. The Managing Director could also use a computer terminal in his office to access current performance on many issues. This information did not, however, extend to 'on-time' delivery. There he relied on the Manufacturing Director to warn him of lateness before he received customer complaints! Together these influences reduced his reports to 30, compared with an average of 144 in the other cases.

The individual reports received by the Managing Directors were examined. Based on this examination two principal themes emerged. The first was the extent to which the reports showed the Managing Directors the level of complexity of production's KMTs. The second was the extent the reports reflected the priorities of production's KMTs. The result of these analyses is presented below.

4.43 The Link between Managing Directors' Information and the Key Manufacturing Tasks

Proposition
Senior managers' information about production over-emphasises output levels / overhead recovery and labour costs and under-emphasises other important KMTs. The reports are generally oversimplistic without sufficient analysis to identify how production can support corporate competitiveness.

While the case studies considered in this section were 'in control', this did not mean that there was no scope, or need, for them to raise performance. I have assumed such improvements are desirable but not always essential. Thus, the following sub-sections are written with the implicit assumption that should the managements of these plants wish to raise their performance, the changes outlined below would need to be considered.

The lack of manufacturing strategies was reflected in the absence of systematically developed statements of key manufacturing tasks, in the 'in control' cases. It was thus difficult to define in detailed terms whether a plant's performance was, or was not, in a state of control. Although the Managing Directors of the plants were better placed than I to make such assessments, it is likely that their perspective of the major manufacturing tasks was limited without this form of detailed analysis. This suggests that their capability to evaluate performance must have been impaired.

Table 6. A Comparison of KMTs and Information Received by the Managing Director of the Clutch Case

Main Key Manufacturing Tasks	Control reports received	Deficiencies in reporting
Cost to support price	Labour efficiency reports. Weekly and six weekly.	No examination of total plant hours against number of standard hours produced
	Capacity utilisation on recent investments	
	Report on value of WIP in assembly. Weekly valuation of stocks	Did not differentiate between delays from shortages in internally made and bought out items
	Report on value of daily output of plant.	
Quality	Warranty claims analysis	No measures of cost of quality. Analysis of faults limited to design weaknesses. Did not extend to weaknesses at production level.
Delivery of orders	Availability of items in stock-planning i.e. 1 or more item in stock. Analysis of daily sales v. targets.	Did not reveal critical measure of level of customer service.
	Load planned for next three months. Monthly statement on value of back-orders, items over £1000 and the number of weeks since stocks were at 1 or more items	No analysis of number of cancelled firm orders or addition priority one items.

In addition to the reports listed above the clutch case Managing Director received a full set of monthly accounts, copies of the minutes of all meetings held in the plant and a monthly report on the functioning of their departments by all heads of departments.

His approach to the control of production is shown in the following comment he made to me during an interview:

> "I monitor the plant (selected items) to make sure that the money we invested in them is being well spent. The monitoring of the assembly shop (low performing) is to make the Superintendent know that I am aware of his output and the work load on his department".

In the pump case achieving a high 'stockturn' was identified as 'very important'. Performance in this dimension had improved from 7.5 turns p.a. to 12 over a

two year period. He anticipated that with the introduction of the MRP II computer system, this would be further increased. The target of a 20 times stockturn had been set, to be accomplished within a further two years. This dimension of performance was monitored via the monthly accounting system.

Three weaknesses can be identified in the pattern of control reports received by the Managing Directors. These patterns were most evident in the clutch case and least evident in the medical products case. The weaknesses were:

(a) The monitoring of labour and output levels appeared to be over-emphasised

(b) Some important dimensions of production performance were not monitored

(c) Some of the reports needed more analysis, rather than summarising of data.

It has been shown above that the performance of production in the 'steady state' paradigm of control is likely to concentrate on the cost of production and labour efficiency.

4.431 Critical review of the dimensions of performance monitored.

A clear pattern in the aspects of performance that were monitored was detectable in the four 'in control' cases.

The output achieved per month, (and in some plants, daily / weekly), was universally given close attention by the plant Managing Directors. It was evident that the value of the months production was considered to be critically important. In the discussion with the Managing Director in the clutch case and the other Managing Directors, it emerged that they considered that the major factor affecting their approach to output value was the influence of their respective group's accounting systems. A drop in value would lead to an adverse variance in the plant's performance and thus a degree of scrutiny from the centre, which would restrict their control over the plant. This emphasis was most evident in the ceramics case, where the Managing Director stated:

"...month by month my main aim is to get sufficient output into the

> warehouse to meet the particular budget. I achieve this by getting my production control people to issue what is available to be made in that month and having a weekly arrears meeting....I keep the pressure on arrears with the objective of making everything production control say is available to make....In some months there is clearly not enough work in theory on the shop floor to make and hit the budget figure...then one is obviously looking for work to bring forward to enable me to at least get a factory breakeven, even if it means putting stuff into the warehouse that is not going to be sold for some time...the way we have set up the budget here means the prime thing is to not get a factory loss (failure to recover the overhead).

This gives strong support for the view that the value of output and / or overhead recovery tends to be more important than producing to schedule specific part numbers. An essential qualification must be made about this claim. I was unable to find any evidence via the production control records of 'high value' parts being produced earlier than lower value parts.

I questioned each of them about which items were to be completed in order to achieve the monthly value. In the clutch case, the Managing Director did not express an opinion on what items were / were not produced, other than achieving an elimination of the backlog in orders. In the pump case, the Managing Director considered that the Stock Controller was responsible for the balance of items via the orders he placed on the plant. However, it was evident that with an average of over one months WIP, the plant did have some discretion on which items it gave priority to, at the final stages of the month.

4.432 Critical review of the dimensions of performance not monitored.

In none of the cases was there any measurement / control of the percentage of on time delivery, either to the customer or to the warehouse. In the absence of such a measure and the presence of strong interest in the total value of output, the risks of some distortion in favour of high value items was a possibility. The traditional measures of individual, section and works labour performance were evident in the four cases. In both the clutch and pump cases, the Managing Director received reports listing the weekly performance of individual production operators.

This level of detailed information appeared to be unnecessary at Managing Director level. In the clutch case, industrial engineering were experimentally producing a report on the number of standard hours produced. At the time of the research, the forward load on the plant was not expressed in standard hours, either in total or in the preferred form of load by key resource centre.

The omission of quality data at Managing Director level was considered to be serious, given the importance assigned to quality by the Directors themselves. The Managing Directors in the clutch and pump cases had good information on warranty claims showing the cost of claims. However, in neither case did they receive information about the costs of accomplishing quality. The pump case Managing Director used a simple guide to assist him to identify scrap levels. When patrolling the plant, he deliberately passed the central 'scrap' bins. If they exceeded a certain number by the Thursday in each week, he subsequently raised it as an issue at the Friday staff meeting. While such simple approaches have a great deal of merit as low cost monitoring devices, they are insufficient guides, where the cost of accomplishing quality can be a critical aspect of performance. In the ceramics case the Managing Director delegated all quality issues to the Manufacturing Director. As such he neither knew the full cost of quality nor had an adequate picture of the plant's outgoing quality levels.

4.433 Weaknesses in the analytical content of reports

Examination of the Managing Directors' reports in the four cases showed a common pattern. All four received reports which primarily concentrated on the provision of raw or summarised data rather than analysed information. I considered the types of 'analysis' which were most likely to be of benefit; comparison of actuals against standards, examination of trends and the identification of causes.

Clearly, analyses lead to costs which are only worth incurring if they are likely to lead to better decisions. I did not make an economic appraisal of any lost benefits of any shortfalls in analysis. However, I approached the need for analyses from the perspective that there should be a good logical 'a priori' case prior to their being undertaken. Some reports were clearly used as 'psychological' controls, and thus did not require supporting analyses. The report on the output of the clutch case assembly department fell into this category. The Managing Director reported that:

> "...I do so (monitor output), so that he (Superintendent) knows that I am looking at it and (he) will therefore improve his performance."

Where reports were used in this way I did not evaluate their scope for quantitative analysis.

I have already shown that quality improvement although considered important, was essentially an unmeasured KMT in the clutch and pump cases. The only reports received by the respective Managing Directors were the warranty claims analyses. These reports were limited to classifying the type of faults and presenting a summary of them by product type. The reports also gave the total cost of meeting the claims per month. This information was clearly valuable and acted upon, with the Managing Directors seeking to achieve warranty costs of 2% in the clutch and >1% in the pump case. There was, however, no systematic examination of trends or presentation of the relative costs of one type of fault compared with the others. They reflected the Pareto principle by starting with the largest number of faults and working down towards the small numbers. Such reports do not require analysis every month but could, I consider, have been improved by undertaking a review of the relative costs at six monthly intervals. As well as not making adequate use of the warranty data, there was no analysis of the considerable volume of 'quality control' data, that was generated from the 'Statistical Quality Assurance' programmes that both plants had adopted. Thus, even when limiting the nature of any analysis to that proposed in traditional

concepts of production, the analytical content was low. When considered against the need to reduce complexity and uncertainty, as in the revised paradigm, the analytical content fell substantially short of requirements.

A similar argument for analysis can be made in respect of delivery performance in the clutch and pump cases. Although the summary of the reports revealed that the Managing Directors received 14.9% and 16.4% of their reports on this topic, detailed examination showed that they were primarily about sales and not delivery. Furthermore, the limited information apparently on delivery performance was in fact simply a statement of 'availability' of one or more items in stock. Given the importance attached to delivery in the KMTs, goal performance in this area needed not only to be measured but its trends to be analysed.

A similar failure to analyse 'work in progress' occurred in the clutch, but not in the other cases. Yet in the clutch case, as explained above, the Managing Director was concerned over the high inventory levels. Despite this there was no measure or analysis of such dimensions of performance as throughput times, lead times by product type or of setup times.

Overall the examination of the Managing Directors' reports showed a strong emphasis on simple reports about output and labour performance, a lack or weakness in the measures about other KMTs and a tendency for those reports that existed to lack appropriate analysis. Such a combination was adequate when it came to revealing a major crisis, but inadequate in picking up the more subtle themes required to bring about systematic improvement in performance. However, adding sufficient analytical content to the reports to bring about improvement would, under prevailing conditions, further intensify staff numbers. I discuss in section 6 how a more analytical approach, at less cost, can be obtained by production involving workers and managers in the analysis of their own work.

4.44 The Weakness of the 'Traditional Paradigm' in terms of Senior Managements' Control of Production

Two weaknesses in the traditional paradigm can be identified from the foregoing examination. Firstly, the paradigm has not adequately assisted senior management to regulate the task required from manufacturing. This has, as shown above, led to the manufacturing task demanded being too difficult for the available level of capability within production. Secondly, the paradigm has had a limited effect in stimulating senior management to improve the capability of their production functions. Where senior management have sought improvement in manufacturing capability, the major focus of attention has been the staff functions. This has not been matched in either production management or workforce development.

The principal area of concern in terms of the difficulty of the task was the lack of involvement of production in the strategic process. Thus decisions about the product range, mix, rate of innovation etc. were taken which led to undesirable conflicts between the performance criteria needed to compete successfully.

In terms of the 'capability to control' the principal areas of concern were shown to be; the division between line and staff responsibility, the lack of monitoring of long term trends and the relatively low concern with training of production management and workforce.

The foregoing can be represented in the following Figure which demonstrates the issues given inadequate attention when using the traditional paradigm.

Figure 7 Issues Inadequately considered by Senior Management in the Traditional Paradigm

Difficulty of the Manufacturing Task	Capability of Production Management to accomplish the Task.
Integration of Manufacturing in the Corporate Strategy.	Organization of the Plant
- Product range and mix	- Structure of Line and Staff responsibilities
- Rate of product/ process innovation	- Monitoring of progress
- Diversity in KMTs	- Commitment to training programme

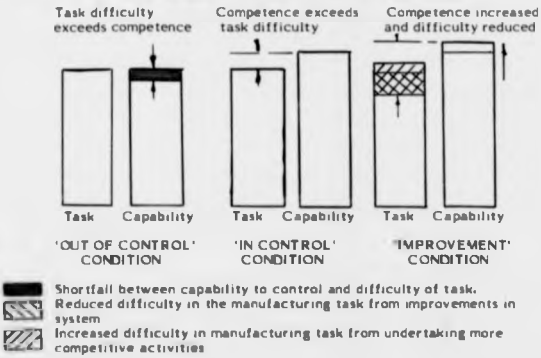
4.5 PRODUCTION MANAGEMENT'S CONTROL OF PERFORMANCE

I showed above how senior managers in the 'in control' cases adopted the traditional paradigm in their control of production performance. They redressed the tendency of their production system to go 'out of control' by making step changes to the systems to restore competitiveness. I showed the limitations of senior managers' attempts to counter the growth of complexity of the manufacturing task and how a number of their step changes intended to restore competitiveness could lead to even more loss of control. Furthermore I showed that their control of routine events was weakly linked with the KMTs which they had earlier identified as important. I now examine the way in which production managers approached their operational level control and how they linked this to the corporate priorities.

4.51 Production Managers and the Difficulty of the Manufacturing Task

In this thesis I treat the level of difficulty of the manufacturing task as a relative rather than absolute measure. Thus, a manufacturing task which is difficult for one set of managers could be relatively easy for another set of managers. The critical relationship is between the complexity of the task and the competence of the particular managers concerned. This relationship is illustrated below in Figure 8.

Figure 8 The Relationship between the Complexity of the Manufacturing Task and the Competence of the Production Managers.



Although the initial complexity of the manufacturing task above is shown at a constant level, it could just as easily vary as the level of managerial competence. In examining the state of control and the way in which production management worked, it was necessary to consider how they dealt with the complexity of the task and how they developed their competences to handle tasks which were necessarily complex.

The traditional paradigm of control within production is based on achieving a higher level of production managements' competence than difficulty in the manufacturing task. If the task's difficulty equals or exceeds this competence the system becomes 'out of control'. If the level of management competence is increased more than the difficulty of the task and / or production management reduces the difficulty of the task, the plant will move into the 'in control' or even the 'improvement' state. At the higher levels of the latter state the gap between difficulty and competence is subsequently reduced. This happens when the firm learns to exploit the strengths of its manufacturing system as a means of competing. The plant remains 'in control' but at a more competitive level. Such

classifications are inevitably imprecise; despite these limitations, they represent an important set of differences, particularly over time.

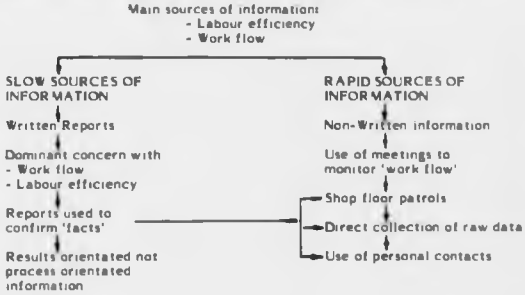
The difficulty of the manufacturing task in the 'in control' cases has already been explored. We now turn to the competence of the production managers to exercise control. Two factors affecting their competence were considered. Firstly, what type of information did the production managers receive and secondly, what, if anything, did they consider it important to learn in order to improve their competence.

4.32 The Diversity of Information Received by Production Management.

Proposition
Production management seek their information from a wide variety of sources. They use information from their own sources to overcome the delays in the formal written reports. The 'formal' reporting system is primarily used to check what is reported about production and to confirm information obtained earlier.

The traditional paradigm primarily concentrates on the formal reporting systems used in production management. Examining the evidence I became more aware of the variety of sources of their information and how they used it for varying purposes. Figure 9 below sets out the principal relationships between the various sources of information. It also introduces how they were used to complement each other in the process of controlling.

Figure 9 The Relationship Between the Various Sources of Information used by Production Managers



4.521 Preferences in the sources of information

To examine the proposition outlined in 4.52 above, I established by means of a questionnaire, the priorities of the production management teams for information from the alternative sources. Their preferred sources of information are summarised in Table 7 below.

Table 7 Production Management's Preferred Sources of Information

SOURCES OF INFORMATION	CASE STUDIES CERAMICS	CLUTCH	MEDICAL	PUMPS	OVERALL
PRODUCTION MGT'S OWN SOURCES					
Personal contacts	2	1	3	3	1st
Production meetings	1	3	2	2	2nd
Touring the plant	3	2	4	4	4th
STAFF BASED SOURCES					
Written reports	4	4*	1	1	3rd
Non-production meetings	5	4*	5	5	5th

* joint score

Table 7 shows that the two most preferred sources of information were production meetings and personal contacts. Both sources were based on 'face to face' contact between the provider and user. Indeed, were it not for the unusual

score of 1st place for written reports in the medical case, the first three preferred sources would all have been under the direct influence of the production manager / supervisors. The high score for written information in the medical case can probably be attributed to the fact that the main information providers reported directly to the Manufacturing Director, who actively ensured that they produced information which was useful to the users. Nevertheless, the fourth place assigned to 'touring the plant' suggested that the managers did not give high priority to observing the small fluctuations in performance, whether in quality, output rate or in plant condition, that led to uncertainty and thus to the build up of buffering devices. Given that such details are not shown in the traditional system of control reports, it is only through the system of 'managing by walking about' that they will be identified. That the majority of management teams in the 'in control' cases did not do so, suggests they were either unaware of these fluctuations or they considered them uncontrollable. The formal 'written' information system was ranked third in importance. However, it should be noted that the perceptions by individual managers of the importance of written information differed more substantially than of any other source of information. The low ranking of written information is significant given its central position in the the traditional paradigm of control. The paradigm is predicated on the premise that the line managers control via information provided by specialist staff. The role of the specialist is generally considered to be identifying what data should be collected, performing any necessary analyses and producing the 'routine' report for line and senior management. Yet, it is evident from the above, that production managers prefer their own sources of information to the staff based reports. These findings need to be considered to establish whether they come from weaknesses in the reports or whether they indicate a weakness in the paradigm.

4.522 A comparison of the speed in obtaining information written v. non-written sources

Figure 9 above argued that production management sought information from more rapid sources than was provided by the routine written reporting system.

To meet the need for rapid information the managers developed a number of alternative means of obtaining the information in time to take the necessary decisions.

Three aspects of performance were most noticeably affected:

(a) Information about production levels
(b) Information about attendance / idle time levels
(c) Information about scrap / reject levels

In all three instances, supervision required to know either the same day an event occurred, or at the latest, the next working day. I compared the time at which the Production Supervisors first knew the facts from their own sources with when they knew the same data from the written reporting system. The results of this comparison in the pump case are shown below as Table 8.

Table 8 Comparison of Time to Obtain Information: Direct v. Formal Systems (Pump Case)

ASPECT OF PERFORMANCE	HOW SUPERVISORS OBTAINED THE INFORMATION AND WHEN	TIME FOR FORMAL REPORTING
Production levels	(1) Night shift record book (2) Morning meeting Information and consequences known by 1100 each day	1-3 days
Attendance & idle time	(1) Unclocked cards examined in racks within 15 mins. of each shift starting (2) Idle time known following day from booking records (0830)	Average 9 days
Scrap / reject levels	Most scrap known by 0830 following day from copies of inspectors' reject slips	Average 10 days

The above comparison shows that information in these three important areas was obtained by production supervision more rapidly than was obtained through the formal written reporting systems used in the plant.

The routine reports on these topics were used to supplement information obtained directly. It is evident from studies of Japanese quality practices that

shop floor workers, as well as managers, undertake a wide range of analyses and thus reduce the need for those made by staff, in addition to increasing their own commitment. These analyses often reach and at times exceed that provided by staff in a number of U.K. companies. Thus, the boundary between 'computer based' analyses and worker / supervisor analyses is a shifting rather than a fixed frontier. If the system is transferred solely to the computer, the onus will remain on staff based control, while if it is placed on supervision, production management will be required to increase their rate of learning.

4.53 A Comparison of the Written Information and the Key Manufacturing Tasks

Proposition
The competence of production management to exercise effective control is reduced by weaknesses in their written reports. These reports do not adequately reflect the priorities of the KMTs; neither is their content adequately linked with decision making in production.

The comparison between the written information (reports) and the KMTs was based on three forms of assessment. These considered the:

(a) proportion of reports devoted to particular themes,
(b) quality of the link between a set of reports and each individual KMT,
(c) value of the reports in distinguishing between good and poor performance.

It was anticipated that the mis-match between the written reports and the KMTs would be greater, the closer a plant was to the 'out of control' condition. Conversely as the plant approached the 'continuous improvement' condition, its written reports would be more closely linked with its KMTs.

In order to make this evaluation a series of scales was developed, which reflected both the 'customer service' and the 'resource efficiency' dimensions of manufacturing performance. Details of these scales are provided in Appendix A.

4.531 The proportion of reports devoted to major topics

While the comparison of the written reports must be directly made with the

specific KMTs applicable in a given plant, it was considered desirable to undertake an initial broad comparison between the pattern of reports in the four cases. The results of this examination are shown in Table 9 below. Comparisons were made between the KMTs / OWC identified by the four Managing Directors, and the written information received by their Production Managers / immediate supervisory subordinates.

Table 9 The Proportion of Routine Control Reports received by the Production Managers on the Major Categories of Performance

Category of Performance	Case Study Ceramic	Clutch	Medical	Pump	Unweighted Average
Physical Quantities	66	46	23	39	43
Plant Utilization	-	24	-	14	9
Plant Load	4	3	6	11	6
Labour Performance	-	5	4	4	3
Stocks and WIP	-	2	20	8	8
Quality	24	2	8	2	9
Financial	1	3	>1	4	2
Sales and Delivery	4	16	40	17	19
Total Percentage	100	100	100	100	100
Total Number of Reports	91	186	106	181	141

Table 9 must be interpreted with caution, as it does not distinguish between the size and quality of the reports. In practice, as would be expected, the reports varied between single and fifty-nine pages, hand written to computerized and differed between great and little value to their recipients. Despite this caveat, the pattern of reports by topic suggests that the Production Managers' attention was being directed to differing sets of priorities. The percentage of the ceramics case reports on output quantities gives an erroneous perspective. This resulted from the use of the 'on-line' computer terminal substituting for some reports and his use of PPC records in the next office. He tended to use their records and discuss load etc. directly with the Production Controller, rather than rely on reports. However, two remarkable differences were worth noting: he received no direct figures on labour performance, nor did he receive stock level / WIP figures, except in the monthly accounting figures.

It can be seen from Table 9 that the reports received by the production management teams were skewed in favour of the efficient use of resources rather than the level of customer service. It shows an emphasis on reporting the level of physical output in the cases. It also shows that the theme of quality received scant attention. The examination demonstrated that while considerable information was provided about sales demand, none was provided explicitly about delivery. The measures most closely reflecting delivery performance were in practice based on a simplified version of the availability of items in the finished goods store.

The extent to which this volume of data was, or was not, reflected in the quality of information is discussed below.

4.532 The Quality of the link between production management's written reports and their KMTs.

To assess the quality of the linkage between the production management teams' written reports and their KMTs, I devised a rating system which gave a score to the quality of this fit. The scoring system was composed of two parts. The first gave the relative importance of the various dimensions of performance. This value was unadjusted for its importance in terms of corporate strategy. Thus it was theoretically possible to achieve an excellent score on an unnecessary dimension of performance. This weakness was overcome by using a second score which showed the importance of the particular dimension of performance. To facilitate the distinction between them, I presented the former as numbers and the latter as letters. The result of these reviews is shown below in Table 10.

Table 10 The Quality of Fit between Reports Received by Production Managers and their Plant's KMTs

	DIMENSIONS OF PERFORM-ANCE	Ceramics MD's Prior-ity	Ceramics Eval-uation	Clutch MD's Prior-ity	Clutch Eval-uation	Medical MD's Prior-ity	Medical Eval-uation	Pump MD's Prior-ity	Pump Eval-uation
(1) Measures of Customer Service	Delivery	B	4	B	4	B	3	B	4
	Flexibility	B	5	D	5	C	5	C	4
	Cost	B	2	A	3	A	2	B	3
	Quality	A	2	A	4	A	2	A	3
	Sub-score	1.5	3.25	1.75	4.00	1.75	3.25	2.0	3.5
(2) Measures of Resource Efficiency	Labour Prod-uctivity	C	4	C	2	B	2	B	2
	Machine Utiliz-ation	D	5	C/D	3	E	(5)*	D	3
	Inventory	C	3	B	4	B	3	B	3
	Quality costs	B	4	B	3	B	3	B	3
	Sub-score	4.0	4.0	2.5	3.00	2.75	3.25	2.75	2.75

(Scoring system: Evaluation of reports: 1 = Excellent, 2 = Very good, 3 = Fair, 4 = Weak, 5 = Poor. Priority of performance: A = Essential, B = Very important, C = Important, D = Slightly important, E = Unimportant)

(*) No report received

Examining Table 10 it can be seen that:

(a) the reporting system in each of the case studies was evaluated as providing better information on resource efficiency than on customer service.

(b) conversely the evaluation showed that there was a greater need for customer service information than for resource efficiency information.

(c) the measures of resource efficiency receiving most attention (labour efficiency & machine utilization) were considered less important than those (inventory & quality costs) receiving less coverage.

(d) the most extensive gap between the information provided and required, in terms of customer service, is about delivery performance. The deficiencies in reporting on flexibility and quality were also significant.

(e) the only item of information which was over-reported was labour efficiency.

Thus it was concluded that there was an inadequate link between the control reports received by the production management team and the way in which senior management identified the plant as competing in the market place. Furthermore, the more emphasis the production management teams gave to the information they received, the greater would be the problems created. This would be particularly so in respect of the likely trade-offs between labour efficiency and quality. To a lesser, but still important, extent there was also scope for conflict between the

machine utilization measures and controlling the level of inventory.

It was also noted that the ranking of the scores for the measures of customer service in the cases was consistent with my assessment of the extent to which each case was nearer to the 'out of control' or 'continuous improvement' condition.

4.533 The value of the production management's written reports in distinguishing between normal and abnormal performance

I examined the written reports received by the production management teams and interviewed the managers to establish their views on the content, frequency and timing of the reports. I established that the reports fell into three groups:

(a) those without standard,
(b) those dealing with summarized data against standards,
(c) those showing individual performances (products or people) against standards.

My central interest was whether the reports distinguished between normal and abnormal performance. Further, were abnormal performances treated as random variables, mistakes or as a basis for learning about the system. Discussion on the latter point is deferred until later to give it greater attention.

A major example of the non use of standards of performance was in the daily reports on output levels. The reports were usually listings of the quantities produced. Only in a limited number of instances was output compared with standards, either work measurement or capacity. The reports did not show the effects of current performance on the ability to meet future requirements. They made little use of standard hours as a measure of load or capacity, although the work content varied by a ratio of 10:1. None of the output reports in the clutch case measured capacity. In the pump case two thirds did so but only in terms of the number of 'average' physical units per shift.

An example of how these weaknesses could be overcome is shown below.

Assume a planned output of 1000 units to be achieved in five equal daily lots of 200 units. The output on day 1 was 100, and to meet the weekly target daily output would need to rise to 225 units. This new daily target could then be compared against the daily capacity and corrective action taken, if necessary. Where it was required the output and capacity could be given in standard hours and even adjusted for departmental performance.

The type of information discussed above is not always necessary. However, I considered the lack of attention to the implications of current production on the future in the clutch case was significant. I also considered that the lack of suitable capacity measures in the pump case would limit production management's ability to plan and control effectively.

The use of aggregate data and standards occurred mainly in parts of the costing and quality control systems. The production management cost data fell into two groups; product costs using standard costing and monthly management accounts, including statements of the expenses. The costing reports distinguished between different products, but hid the effects of small versus large volumes and the consequences of production by different operators. The one distinction commonly made was deviations from the specified route, and in these circumstances costs were computed and reported. Similarly, much of the internal quality data was also provided in an aggregated format.

Quality was shown in Table 10 above to be important in all four cases. It should also be noted that all the cases had customer approved SQA systems. Thus, I was dealing with plants which sought good quality and had been audited by quality control specialists.

Production management in the clutch case received one weekly report. It showed the quantity rejected in goods inwards, machine shop, and assembly. The report stated the part number, the quantity rejected and the cause. Analysis of the data showed the reports to be inaccurate. In one instance I established that

it stated the level of rejects was 2.06%, when the correct figure was 4.13%. The variation in reject rates between products was not recorded. However, I calculated that they ranged from 0 to <19%. A production manager would be unlikely to have the time to make these analyses. The effect of such variation on uncertainty was not recognized by the production managers concerned, who considered 'normal' as covered by 'scheduled averages'. In fact these averages were less than the levels found in practice. The data recorded rejects by the line making the part, but hid the effect of rejects by product types. This could not normally be retrospectively calculated from the report. Although the rejects were divided into operator, machine and supplier scrap, the percentages of each were not shown, nor was the data broken down in the form needed to take corrective action. I concluded that the weaknesses lay in the presentation of the reports not in the data collected. It will be seen from the above that the quality control system, despite being an approved SQA system, was not linked with the production management to enable the systematic control of inplant quality levels. The internal information that was available was often hidden in the aggregated form discussed above.

Several of the reports received by the production management teams presented information about individual products and / or people in the system and compared them with either explicit or implicit standards of performance. The labour reports mainly fell into the implicit group. They did not show the target performances for operators or departments, although the managers all expressed clear goals about the overall levels of performance they expected to achieve.

4.5.1 The value of the production management's written reports in identifying trends in performance.

I examined the reports received by the production management teams to see whether they received any information about trends in performance. I used a dBase II computer program which I wrote to give the 'cumulative sum' values of performance levels over time. I reinforced the quantitative examination with discussions with the users about each document. In two areas, warranty claims and labour performance, I obtained six month detailed historical data on performance.

The production managers' reports were mainly about the costs of scrap. The definition, however, was narrow. The data did not enable them to check whether quality levels were changing over time. In the pump and medical cases some trends were reviewed. In the pump case this was limited to the warranty claims but in the medical case the trends in 'in plant' rejects were also monitored by the production manager who developed his own records to identify trends in quality performance. In both cases the central interest was on the cost of rejects, but in neither case was the data provided which would give them the full costs of rejects etc. Unlike the data about 'in plant' quality in the pump and clutch cases, their warranty claims data identified the claims by specific products so that any redesign or changes in their means of manufacture could be made.

Although the production managers did not receive information showing the trends in labour performance, I demonstrated that such analysis was possible from the data they received. I did so, in the pump case, for operator performance and total labour employed. The analysis showed that productivity was increasing and that total labour employed in the plant was declining as a ratio of the number of production direct operators. These improvements reflected the Managing Director's interest in reducing 'indirects', but was given new clarity by the revised form of analysis. When this information was shown to the Production Manager he expressed surprise at the much earlier detection of trends in performance. However, as noted earlier, no initiatives were undertaken within production to reduce the 'demand' for documentation (and thus overheads) by modifying

the conversion system.

In this and the preceding sub-section I have shown that the reports received by production managers had limited value in detecting either abnormal from normal performance or in detecting trends. Clearly, this did not apply to major deviations, but it can be argued that these would be known anyway. It is in identifying real but comparatively small trends and deviations that the written reports are most suitable, and were least effective.

Indeed, when I discussed their written 'control' reports, I found that production management did not expect to use them to exercise control. This was shown to be so in the clutch case, where the Production Manager said:

> "I use the written reports in order to see what is said about us, rather than to control. I could not control with the information they (staff) provide as it's too late to take action when it arrives."

As shown by the above statement, the Production Manager used the non-written sources of information when he needed information in order to control. The written reports were either used to 'confirm information already known' or were simply redundant in the face of faster information gathering methods used by the supervision.

The examination showed that the production management teams in the 'in control' cases lacked reports which could have helped them evaluate whether they were making adequate progress towards these end goals. Without such information, there was little likelihood of movement into the 'continuous improvement' condition.

My interviews with the report users showed that they expected variation in the daily output. When none occurred they suspected false booking or worker controlled output levels. This expectation of variation in performance, combined with a lack of means of quickly identifying real trends, reinforced the traditional

perspective that production management's primary role was to maintain, not improve, performance. It also supports the view that they did not understand the importance of the link between uncertainty and the control and improvement condition.

4.54 Non-Written Sources of Information

Table 7 showed that production managers in the 'in control' cases considered that personal contacts and production meetings were their two most important sources of information. 'Touring the plants' was placed fourth in importance of information sources. Non production management chaired meetings were almost universally considered the least important source of information.

4.541 Information gathered at meetings

The analyses of the production management meetings showed a strong emphasis on rapid feedback of information about output. They also demonstrated that they were not used to eliminate problems. The Production Manager in the clutch case provided a particularly clear picture of his purposes for holding these meetings. These are summarised as follows:

(a) dissemination of company information to subordinates
(b) a vehicle for staff training
(c) a means of seeking solutions from subordinates
(d) a means of increasing co-ordination within production and with PPC

In particular he emphasised the training and solution dimensions of the meetings saying:

> "I want them to see how corrective action should flow from a problem ...to get them to understand what they can do to solve a problem, as distinct from reporting its existence."

The proportion of time spent on the various themes in the meetings was examined.

This shows that 37% of the meeting's time was spent obtaining data more

rapidly than was achieved by the written reporting system. The main information where this speed was sought involved the quantities produced at various stages of production and the report of their current location. This rapid exchange of information was necessary as the physical movement of the product was much faster than the 1 to 3 days delay in the computer based system of monitoring. It was particularly important in the context of items which were being 'urged' through the system.

The main emphasis in these meetings was on total output, rather than output of specific products. This observation was confirmed on a number of occasions in 'informal' discussions with those attending the meetings. The most explicit comment came from the Production Manager who said,

> "It's production's job to get the total volumes out, it's other people's job to control the rest."

Delays caused by material, tooling or labour shortages led to nearly 32% of the discussion. Additionally a further 18% of time was devoted to finding alternative work in these circumstances. It can thus be seen that 50% of the time of the meetings was devoted to the consequences of uncertainty. It is also evident that the meetings were used as mechanisms for handling the consequences of the uncertainty, rather than for seeking to eliminate (or even reduce), the complexity that existed. With five people attending these meetings of 30 minutes duration, the weekly loss of time was 12.5 hours in management meetings. The loss of time on the shop floor was considered likely to be high.

A further 55 minutes discussion about delays and their consequences took place in the weekly 'Accountability' meeting. Despite the considerable time devoted to this theme, at no time was I able to find any positive actions being undertaken to eliminate the primary causes of the delays.

The production meetings in the clutch case tended to reflect the more marg-

inal 'in control' state in this case, than in the pump and medical cases. In the pump case, the production meetings were conducted in a more proactive environment. There remained a heavy emphasis on monitoring the location of work, so that smooth workflow could be maintained. However, this represented a smaller proportion of the meeting. The remainder of the time was spent on planning how to make future workflows operate more smoothly.

4.342 Information gathered from personal contacts

Although information from personal contacts was given the overall highest score in importance as a source of control information, I was unable to examine this dimension of the production managers' work without changing the nature of the investigation and lengthening what was already a large study. I therefore decided that, despite its importance, I would not examine this source of information. Clearly work is necessary on this theme, but I consider it requires forming the centre piece of another study, rather than being a peripheral component of this research.

4.343 Patrolling the shop floor as a means of obtaining control information

Shop floor patrols formed a regular part of the practice of the Supervisors in the clutch and pump cases. In the clutch case, the Production Manager was also heavily involved, as a consequence of the Managing Director's daily tour of the plant. No detectable pattern of shop floor patrols was identified in the medical case.

I accompanied Supervisors in both plants and the Production Manager in the clutch case on a number of patrols. In the latter case study, the primary practice was to look for hold ups to the smooth flow of work, (i.e. machines that were idle, material that had not moved etc.). In a number of ways the behaviour of the

Manager / Supervisors was similar to that of a progress chaser. This was consistent with the high level of concern over workflow found in their general approach to their role. In the pump case, the Supervisors were observed to concentrate more on maintaining working relationships between themselves and their subordinates.

The limited data available in this area made it difficult to gauge the wider implications of these findings, (i.e. one case (clutch) was near the 'out of control' condition and in another (medical) patrols were not evident). It seemed, however, within these narrow limits that the non-written sources were partly used to supplement data not collected via the reporting system and partly used to give early warnings to management about the behaviour of workers / the system, to detect when it was beginning to malfunction.

4.55 The Impact of Learning on the Competence of Production Management

Proposition
Production managers do not emphasise 'learning', (and therefore, improvement) as a central component of their role. They tend to have a limited perspective of the direction in which improvements should occur. In addition they do not recognize the extent to which improvements are practical within the manufacturing processes.

The literature review showed the significant role assigned to training (and therefore learning) of Japanese and German manufacturing firms. I, therefore, examined the scope for, and placed on, learning and how it affected their competence to control.

Three themes emerged:

(a) Production managers' view of learning
(b) The scope for learning
(c) What they did (and did not) learn

These themes are examined below.

4.551 Production managers' perception of their role and the impact on learning

Production Managers in the four 'in control' cases, shared a common concern for output levels, labour efficiency and quality. However, within these general issues their priorities differed significantly. In the clutch and pump cases, achieving output was assigned first priority. I asked the Production Manager in the clutch case how he would choose between achieving greater than planned output by not producing all the scheduled items, or meeting the schedule but at the cost of lower total value of output. He declared that he was quite clear that the Managing Director expected him in all but exceptional circumstances to achieve the higher level of output. This emphasis on the value of total output was also reflected in the pump case, where a Superintendent reported that:

> "My job is to get the work out. I will override the systems when I have to.....I will get concession notes when the best machine is not available....I will chase suppliers when the material is not there.... maybe next week I will use the system, because it will suit my needs then."

While the commitment to achieving output by the Supervisor is high, it shows that he views his role as getting the best out of the system rather than changing it. His approach gives precedence to current output, rather than improving competence through developing the manufacturing system. Further, it was evident that he did not perceive there to be any important linkage between the state of control and either uncertainty or complexity. At least, if he did consider there was a linkage, he did not consider it to be part of his task to learn how to improve the system.

4.552 The scope for learning

Considerable scope existed for learning by the production management teams in the four 'in control' cases. The literature review supported by Figure 8 shows learning in two forms; effectively handling existing tasks and reducing the complexity of tasks. The former reflects 'good' traditional practice, while both

forms of improvement would be required in the revised paradigm. Both aspects of learning were considered.

The revised paradigm is characterised by four features. Low levels of inventory, high standards of inter-process quality, high flexibility by the workforce and a significant reduction in transactional documentation. I have previously showed that the production management teams did not receive the information necessary to evaluate the working of their systems in terms of these dimensions of performance. The examination further showed that they did not have suitable information about the end-results achieved. Nor did they possess the information needed to guide them about their progress towards these goals.

4.553 What they did (and did not) learn

The literature review revealed sharp differences in the approach to (and content of) learning between firms following the traditional and revised paradigms. Common to the German and Japanese approaches to production is a high emphasis on technical competence, both in management, and more significantly by the workforce. This differs sharply from the generally perceived approach in British manufacturing firms.

In examining what was learnt in the case studies, I sought to differentiate between formal learning, where some form of certification occurred and informal learning when there was no public recognition of the knowledge acquired.

Information from the personnel departments in the cases showed that most of the Superintendents in the four cases had some form of managerial qualifications. These are shown below in Figure 10.

Figure 10 Qualifications of Managers/Supervisors ('In Control' Cases)

MANAGER'S POSITION	Ceramics	Clutch	Medical	Pump
Production Manager	Degree	None	Degree	BIM (old form)
Supervisors	None	NEBSS B.Sc.Mech. Eng.(pass)	NEBSS Unknown	NEBSS NEBSS

It can be seen from the above that most of the Supervisors either had passed the 'National Examination Board in Supervisory Studies' or had at least an equivalent level of qualification. Thus, within the framework of qualifications, most of these 'in control' cases had taken advantage of the available provisions.

In my interviews with the Managers and Supervisors, I sought to establish what they considered they had learnt (on the job) in the previous 2-3 years. I looked to see whether they considered they, like the Germans and Japanese, had learnt much about the behaviour of their manufacturing systems. In particular, I wished to discover whether they had learnt to reduce the complexity / uncertainties of the manufacturing systems and processes.

In the clutch case there was no recognition of these concepts. In the pump case, some awareness existed and the development of dedicated cells was quoted as an example of developing a much less complex system. Conversely, they also reported fears that the introduction of MRP systems would change the role of the manager, making it less close to the day to day operations. Wild (1986) also recognizes this as a potential difficulty. What was not recognized was that such distancing of production managers from the day to day task reduces the scope for making incremental improvements.

The response in the medical case was similar to that in the pump case. The main learning taking place was via the redesign of long-chained flow lines into small groups / individual workers completing their own tasks.

In none of the cases could I find evidence of close involvement of production management in advancing product quality. Neither could I find evidence of reductions in setup times. Finally, although the production managers in the pump and medical cases both emphasised the importance of skilled workforces, in neither instance could they shown any evidence of systematic worker training programmes. Operators still learnt by initial examples from foremen / setters, followed by working alongside a fellow worker. Sitting with Nellie was alive and well.

4.6 CONCLUSIONS ABOUT THE THE TRADITIONAL PARADIGM OF CONTROL

The foregoing examination of four case studies of plants following the traditional paradigm of control has revealed the limitations of the model as a basis for maintaining a plant at a competitive level in a changing market place. It was evident, in these cases, that competitiveness depended significantly on manufacturing performance. Despite its critical role, there was little evidence to show this 'importance' was reflected in the approach to controlling production.

Although the cases examined were all identified as 'in control' this state was largely achieved by a series of stepped changes to the manufacturing system. As was shown, the changes were primarily introduced from outside the production management team. Such changes tend to be the discrete replacement of old systems and technologies with newer alternatives. Little attention is given to learning to exploit the potential of existing systems, nor of using such information as the basis for designing even better systems to replace them at the appropriate time. As a consequence, some of the changes led to further difficulties in achieving / maintaining control. Additionally, they followed a strategy of attempting to achieve better control via a reduction of the complexity / uncertainty of the manufacturing task. This meant that the systems or mechanisms of

control had to be correspondingly more complex, in order to regulate the high inherent variety in the manufacturing system. Such a weakness is of great significance in an economy which is dependent on manufacturing competitiveness.

The traditional paradigm does not stimulate senior or operational managers to seek a state of control which both maintains stability and is adaptive to necessary change. Production managers are not, in general, recognized as having a significant proactive contribution to make to corporate competitiveness. When improvements are recognized as necessary they fall into two groups: larger improvements which are sought in the form of discrete steps, generally based on capital expenditure and smaller improvements which are expected of production, tending to be limited to productivity.

The written reports, at senior and departmental management levels, which are perceived by the literature to be the central instruments of control, have only limited effectiveness in this role. Their main strength lies in the monitoring of 'resource efficiency' while their main weakness lies in monitoring 'customer service'.

The production management team's written reports not only do not reflect the KMTs of their companies, neither do they contain the type of information needed to resolve outstanding problems. The data frequently arrives too late to be used in decision making. Production management tend to overcome this lateness by gathering their own information either at meetings or by personal contact. Although such information is obtained in time, it is more difficult to use as a basis for analysis of outstanding problems. Thus, the conjunction of the absence of guidelines about where better production performance could lead to greater competitiveness and the lack of suitable information, leads to a low level of learning. This is particularly so in respect of improvements to the manufacturing task.

The weaknesses outlined above can, in the face of strong competitive pressures or in the event of a low level of managerial capability, lead to a loss of control. Regrettably, even if the traditional paradigm is practised effectively, as demonstrated in the medical case, it does not produce the level of control and improvement that is claimed to arise from the practice of the revised paradigm.

5. THE 'OUT OF CONTROL' CONDITION OF THE TRADITIONAL PARADIGM OF CONTROL IN PRODUCTION

5.1 THE 'OUT OF CONTROL' CONDITION IN PRODUCTION

Figure 1 identified three conditions of control: 'in control', 'out of control' and 'control and improvement'. I showed in section 4 that the 'in control' and 'out of control' conditions are both products of the traditional paradigm of control in production. Further I suggested that the traditional paradigm would lead to the 'out of control' condition when the difficulty of the manufacturing task exceeds the capability of the production management team to exercise control. This section deals with situations where this occurred and gave rise to the 'out of control' condition.

> Proposition
> The 'out of control' condition occurs when either the manufacturing task is too difficult to accomplish or when production management lacks the necessary capabilities. The difficulty of the manufacturing task is a function of the way a company competes in the market and the suitability of its techno and infrastructures to support the competitive strategies adopted.

Three of the seven cases exhibited 'out of control' characteristics. The two most serious instances involved plants respectively producing kitchen furniture and brakes. A third, less serious instance involved a department in the clutch case discussed above.

5.11 Causes of the 'Out of Control' Condition

Earlier I developed the argument that the 'out of control' condition occurred when there was a mis-match between the difficulty of the manufacturing task and / or the level of capability of management to exercise control. Based on the above it can be argued that a production unit is 'out of control' when it is unable, over a sustained period, to satisfactorily complete its required manufacturing tasks. A second criterion was identified in the literature review. The cybernetic principle of ultrastability showed that systems go out of control when they fail to maintain sufficient internal stability. Failures of either type have adverse effects on competitiveness.

It was shown above that the complexity, and therefore difficulty, of the manufacturing task is largely a function of corporate competitive strategies and their means of execution. The literature showed that the traditional paradigm does not adequately address the link between strategy and complexity. This reflects the assumption that the production system is inevitably complex and uncertain. This assumption was challenged in the manufacturing strategy literature, which showed how to reduce the complexity of the manufacturing task via the focus concept and internal coherence. Section 4 showed that in the absence of manufacturing strategies the difficulty of the manufacturing task tended to increase in the four case studies.

5.12 Evidence of the 'Out of Control' Condition

The 'out of control' condition in the 'out of control' cases was identified by comparing production performance with the KMTs or OWC set out by the respective senior managers. (These KMTs and OWC are shown below in the sub-sections considering the quality of fit between them and the information provided.)

The brake case failed to meet output levels and cost standards. The original equipment and service output was reviewed over a six month period; this showed that 15% of the original equipment parts and 20% of service parts were not completed to schedule. Overall labour costs were more than 60% over, and a representative product's total costs nearly 31% over, budget.

In the kitchen furniture case the main failure was the 'on time delivery of complete orders'. Delivery promises were broken for 38% of orders. As the majority of broken delivery promises were for larger orders, the overall effect was the late delivery of 67% of the items ordered.

As noted above, the problems in the clutch case were mainly in the assembly

department. Output was 10% below target levels, but was achieved in an atmosphere of dis-order and frantic expediting of components from the machine shop and purchasing. Component shortages led to considerable re-setting and breaking down of products on the assembly equipment. This subsequently led to other delays in production and deterioration of quality.

5.2 THE CAUSES OF THE 'OUT OF CONTROL' CONDITION

Figure 8 showed that the 'out of control' condition is created when the difficulty of the manufacturing task exceeds the capability of the production management team to accomplish the task. I showed above that the mis-match occurs via two forms of incongruence; either between the task and the process technology / procedures, or between the task and management's capability to exercise control. Both mis-matches can be triggered by changes in the manufacturing task to support corporate competitiveness. The following proposition emerged from the above discussion.

> Proposition
> The 'out of control' condition occurs when either there is a mis-match between the corporate strategy and the manufacturing task or when the manufacturing task and the capability to control are incompatible. The absence of a manufacturing strategy contributes significantly to both types of mis-match.

5.21 A Lack of Manufacturing Strategy

Discussions with the Managing Directors of the kitchen furniture and brake cases revealed the absence of manufacturing strategies in either case. Although many changes were being made within the companies, to help them compete more effectively, they were primarily defensive and lacked the perspectives found in manufacturing strategies.

In the brake case the Managing Director was interested in developing a manufacturing strategy, but it had not as yet been formulated. However, some

action was undertaken to reduce the complexity of the manufacturing system, and to reduce the extent of the process - task mis-match. These plans consisted of a limited application of the 'plant within plant' concept and use of CNC machinery to produce smaller batches and achieve closer tolerances. At the time of the study a small 'plant within plant' section had been implemented.

In the kitchen furniture case neither the Managing nor Manufacturing Directors were aware of the concept of manufacturing strategy nor did their practices cover the type of issues involved. A similar lack of awareness existed in the clutch case. In both instances, policy decisions were mainly communicated verbally between senior and production management. This tended to limit the scope for detailed examination of alternatives. This suggested to me that senior management did not recognize the link between their policy decisions and the control of production performance. Related to this was the question in both case studies of whether senior management possessed / sought the information needed to inform them of the effects of increasing the level of difficulty of the manufacturing task on the control of their plants. If they possessed such information, did they have a strategy to enable their manufacturing function to be restored to effective levels of control?

The above examples demonstrated the high levels of difficulty of the manufacturing task in the 'out of control' cases and the absence of manufacturing strategies which would help corporate management to recognize the link between the complexity of the manufacturing task and the control of production. In all the 'out of control' cases, attempts were made to escape from the condition through technological changes in the manufacturing processes.

Senior and operational managers in the clutch and brake cases strongly suggested that the 'out of control' condition had arisen recently as a consequence of the increased pressures on production, as their firms sought to improve their

competitiveness. However, the Works Managers in the kitchen case did not agree, arguing that fire-fighting was simply more intense as a result of increased difficulty in the manufacturing task over the past two years.

5.22 The Impact of Increased Competition on the Difficulty of the Manufacturing Tasks

I examined the competitive pressures in these 'out of control' cases to see whether they led to the expected expansion of the product range and thus to greater manufacturing complexity. Investigations in the brake and clutch cases took place in 1981-2, when a major contraction occurred in the automotive industry. The kitchen furniture case was studied in 1985-6, when imports from major European producers challenged the company's leadership of its market sector. Table 11 below summarises the main changes to the manufacturing tasks in these case studies.

Table 11 Increasing the Requirements Affecting the Difficulty of the Manufacturing Task

CHANGES IN MANUFACTUR -ING TASK	Brakes	Clutches	Kitchen Furniture
Increased Product range	Range increase from 2 to 6 families of products. (Output reduced by by 40%)	224 new designs / modification and 263 Engineering changes in 2 years	From 197 to 452 lines and 11 to 18 ranges in two years
Reduced Inventory Levels	Cut WIP from £9m. to £6.3m. Make components in same month as assembly.	Inventory cut from two to one months supply.	Cut total stocks by 13%, (59% adjusted for increased output)
Improved Quality Levels	Tolerances on the new products reduced to one tenth of previous levels	Commitment to reach grade A from Grade B and below SQA levels	Major review of quality (subjectively assessed)
Reduction of Costs	Cut production costs by 30%.		Cut production cost by 3%.
Shorter Lead Times	More flexible output, matching demand.	Hold current costs for 2 years.	Specials from 6 to 4 weeks

Two types of changes in the manufacturing task are shown in Table 11. In the kitchen furniture and clutch cases the type of task remained similar, while the complexity increased. However, in the brake case the nature of the task become more difficult as the plant was repositioned on the product-process matrix. Smaller batches with more frequent changeovers, and closer tolerances, were required. These were difficult to achieve on the highly dedicated plant. To a lesser extent incongruence existed between the task and process in the kitchen furniture case as the product range expanded and production of 'specials' grew in importance. Against this background of change, production management in these cases was slow to meet the changes and this tended to exacerbate the 'out of control' condition.

Structural inconsistencies between the processes / procedures and the manufacturing task have been given the title of 'process and profile mis-match'. They typically occur as above, when changes take place in market requirements, so that the relative importance of price, quality, delivery speed etc. change from those previously incorporated in the design of the process and procedures. Consequently the manufacturing processes and procedures are no longer adequate for the tasks they are required to perform.

The two principal 'out of control' cases highlighted the differences between increasing the difficulty of the task and changing the nature of the manufacturing task. The increased difficulty of the manufacturing task in the cases has been shown to arise in response to the need for higher competitive performance. The absence of manufacturing strategies in these 'out of control' case studies meant that there were no formal mechanisms to ensure the manufacturing task was constrained to match the resources available, or that new resources were obtained to meet these revised tasks.

The effect on control was significant. Under this structure the goals which

control sought to accomplish were changeable in both difficulty and direction. The rate of change of such goals appeared to be more rapid than that which could be achieved within production, affected as it is by the physical constraints of the process technologies and the organizational constraints of the procedures used to regulate the manufacturing system.

5.3 WEAKNESSES IN SENIOR MANAGEMENT'S CONTROL OF PRODUCTION

The discussion above revealed three important factors. Firstly, that production performance had fallen short of the necessary levels and thus had led to the 'out of control' condition. Secondly, that the primary cause of this condition lay in the manufacturing task being too difficult for the capability of the present system of controlling production. Thirdly, that the senior management lacked a manufacturing strategy to guide their resolution of technological or infrastructural problems.

The examination above led to further consideration of three ways in which senior management's control of production appeared to be ineffective. The first was the limited knowledge of senior management about the extent of production's control of the competitively important dimensions of performance. Secondly, there was the inadequate extent to which the system of control made clear the level and rate of improvements in production performance required in order to restore the plants to an effective state of control in their changing environments. Thirdly, there was the extent to which senior management brought about effective integration between line and staff managers to resolve control problems.

5.31 Control of the Strategically Important Dimensions of Production Performance

Proposition
Senior management reporting systems do not sufficiently reflect the ways in which production performance can support corporate competitiveness.

I interviewed the managers concerned to establish sets of KMTs or OWC, as

the absence of manufacturing strategies meant that they did not have statements of their key manufacturing tasks. In the brake case this was achieved via discussions with Design, Marketing and Manufacturing Managers. The KMTs are displayed in the left hand column of Table 12 below, while the reports received are shown in the middle column. The last column identifies deficiencies in the match between KMTs and the reporting system.

Table 12 A Comparison of KMTs & the Managing Director's Control Information (Brake Case)

	Main order winning criteria	Control reports received	Deficiencies in reporting
(a)	keeping abreast, and possibly slightly ahead of, its rivals in terms of:		
(i)	manufactured quality	none	critical for cost & quality, no basis for comparison with competition.
(ii)	delivery speed	none	not critical for O.E.
(iii)	delivery reliability	none	was low but not reported directly to Managing Director
(b)	improve its ability to compete by:	(a) monthly accounts	lacked information by product group and volume
(iv)	reducing manufacturing costs by 20-30 %	(b) weekly labour efficiency report	detailed monitoring of labour not trends or analysis
		(c) Total hours to standard hours	trends only visually inspected no analysis of underlying causes.
(v)	improve service delivery speed and reliability	none	critical issue not reported
(vi)	reduce lead time to introduce new designs into production	minutes of committee	no use of critical path or resource allocation techniques to reduce lead times
(vii)	minimize tooling costs	single exception report	needs major improvement and routine control
(viii)	support production of more advanced products	none	(not likely to require conventional reports)

OTHER REPORTS RECEIVED

Daily and weekly output	Selective plant utilization
Absenteeism figures	Lateness figures
Forecast of standard hours required per month	Sales analyses
	Warehouse stock report

Table 12 shows a gap between the KMTs identified earlier by the Plant Manager as important, and his reports. First was a series of omissions in the topics covered by the reports. No reports were received on quality, delivery speed or delivery reliability. Secondly, his information was inadequate on costs and on new product introductions which were insufficient for effective control. Examination of the reports revealed weaknesses in the way they presented important information. The missing themes are as follows.

He did not know about the quality reaching customers or about the internal costs of quality. He stated that he relied on phone calls from the Chief Executives of his customers to indicate problems. He stated that he had not realized the deficiency until he discussed it with me.

He considered delivery speed and reliability, covering both original and service parts, to be a particularly critical element in the company's plans to increase its share of this profitable sector. To improve delivery speed had been identified as the first priority in offering a more competitive approach. Despite recognition of its importance, no reports on its performance were provided.

Tooling costs were particularly significant in the context of tenders for new products, as the customer purchased the tools on a separate contract. However, costs and delivery performance were not reported in ways which enabled comparison with the main competitors.

Similar weaknesses in the omission of important dimensions of production performance were identified in the kitchen furniture case.

5.311 Use of substitute control reports

Proposition
Senior management use multiple 'indirect' reports to compensate for the omission of specific reports reflecting the key dimensions of production's potential contribution to corporate competitiveness

The absence of specific reports showing performance on the senior managers' KMTs led to the use of a series of indirect reports.

An example of indirect reports was found in the brake case. The Managing Director used a combination of reports to attempt to regulate delivery performance. Shortages and stock levels were noted from the weekly sales / stock report and compared against daily and weekly output reports. Machine utilization reports were used selectively to examine known bottlenecks. Despite this, he was unable to ensure satisfactory delivery levels. He attributed this failure to inadequacies in the answers provided by the Production Managers when they reported on the shortfalls in output. He considered they did not reveal the important primary or secondary causes of the restriction in output, which inhibited him from taking appropriate corrective action. He claimed that even when the primary problems were solved, secondary problems would constrain output to current levels unless they too were resolved. Despite these views, which were strongly expressed, no evidence was found of attempts to change the reports or to make the Production Managers provide better explanations of the shortfalls.

Similarly, the introduction of new products had been identified as a critical factor in corporate competitiveness. This required new products to be introduced quickly and tooling costs to be reduced substantially. None of the reports dealt specifically with these issues. Instead, the timing of introductions was monitored via the minutes of the product development committee. While this enabled detailed follow up of specific products / components and the departments concerned, it was of limited value to senior management in evaluating progress on reducing the overall lead times. This was, however, needed, to at least match the times of their competitors. Management was aware that customers consider the higher than average tooling costs a disadvantage in obtaining contracts. The costs were monitored via the monthly departmental accounts. While this gave

them accurate accounts, (within the reliability of standard costing systems), of the cost of the toolmaking facility, it did not assist them to analyse the cost of individual tools or to identify how they could be reduced to a competitive level.

In the kitchen furniture case a similar substitution of indirect monitoring occurred in respect of delivery performance.

5.312 Use of partial reports

Proposition
The partial nature of the reports received by senior management further weakened the analysis of production performance because of the limited nature of their content.

Although similar to the use of substitute reports, partial reports differ subtly from them, in that they addressed an important issue, albeit incompletely.

The brake case Managing Director was aware from the monthly accounts that the factory labour variance was 61% over standards. However, he could not identify whether it was localised in particular parts of the plant. Neither was he able to identify whether particular families of products had better or worse variances than the average. This forced him to seek general rather than particular solutions. Similarly, although aware that output for certain families of products was below target, he was unable to identify if this arose from giving inappropriate priority to other items in the range.

Total staff costs were regarded as an important element in works costs. They were monitored using the ratio of total hours to standard hours, which revealed that they exceeded 4:1. The Managing Director paid close attention to the total of the overall ratio, but significantly less to those of the subsections. Five years historical data was available, providing comparative figures for the group's UK and continental plants. Despite this, no evidence was found of his using the information to exercise control over indirect labour costs beyond the simple practice of restricting replacement of vacancies. No form of trend analysis was

undertaken, simply the visual inspection of graphs.

The brake case Managing Director was aware of limitations in his information; in particular he wanted to know the labour contents of the plant load and to measure labour efficiency. The work study department was working on the production of a new report showing the labour requirements of the plant load. The report was inaccurate and slow to produce, as some of the figures were unavailable and all of the calculations were done by hand. The data for these calculations existed in the accounting database, but the Plant Manager was advised by the computer department of a delay of approximately 3-6 months and an internal re-charge of £12,000 to obtain them.

5.313 Limitations of the strategic control information

In both the clutch and the kitchen furniture cases an inadequate link was detected between the pattern of information received by senior management and the role production needed to play in bringing about competitiveness. It was concluded that this reinforced the view that the directors' information was inadequately linked with production's major manufacturing tasks. Although aware of a failure to meet their performance levels, senior management lacked the information with which to review effectively their long term performance.

Not only were important dimensions of performance not covered by reports, but, in addition, in other important areas, the reports received were limited in their content. The limitation of a number of these 'partial reports' was sufficiently great so that managers receiving them could not be expected to realistically control performance on these topics.

The degree to which important themes in the KMTs were either omitted entirely, or only partially covered, strictly limited senior management's scope in

evaluating the rate of improvement in performance. Even where an aspect of performance was covered, the content of the report did not facilitate effective monitoring of trends. Consequently, senior management were unable to adequately gauge whether the problems leading to their plants being 'out of control' were being overcome and, if so, what rate of improvement was being achieved. The only exception to this general problem was that of total costs. The accounting system in the main 'out of control' cases reflected where any overall level of loss of planned profits occurred. Yet in neither case could this information show senior managers where an individual product's 'actual' costs were, or were not, improving.

5.32 The Contribution of Staff to Senior Managements' Control of Production

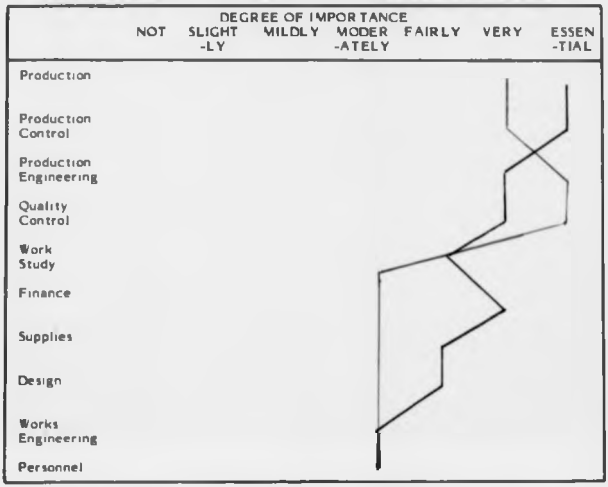
I have shown that senior management lacked the information or analyses to effectively control production. Traditionally responsibility for providing such reports has been given to functional specialists. Earlier studies by manufacturing strategists and organizational theorists have criticised the Taylorian model for fragmenting responsibility for control between the functions. I, therefore, decided to examine how, if at all, functional staff affected senior management's control of production.

5.321 Senior managers' use of staff to control production

Proposition
Where the line and staff system is used, senior management expect staff groups to bring about the main revisions to the manufacturing task.

Senior management in the 'out of control' cases outlined their expectations of the various functions' contribution to competitiveness. This established their relative importance and identified what was expected of them. The latter dealt with how these contributions affected the long term controllability of the plant, and whether these efforts emphasised new systems or the exercise of compliance to existing systems. The result of this discussion in the brake case is shown below in Figure 11.

F[illegible] to Current and Future Competitiveness from the Individual Departments (Brake Case)



——— - indicates current contribution to competitiveness
——— - indicates expected contribution to competitiveness in 3-5 years time

Production was currently considered essential, although it was expected to reduce in importance while production engineering and quality control advanced over the next 3-5 years. Detailed discussion of the roles revealed that the Managing Director considered two aspect of production's task to be important: firstly, achieving target output and secondly, reducing adverse labour variances. Production management's role was only discussed in terms of complying with changes brought about by staff. This was highlighted by the approach to resolving the 'profile mis-match' between the product mix, market requirements, and the technology available, responsibility for which was given to production engineering. This failed to reflect the large number of small improvements which

could have been carried out on the shop floor.

5.322 Differences in the emphasis on using functional staff

Proposition
When a traditionally controlled plant combines a low ratio of staff to direct workers and a growth in the complexity of its manufacturing task, it will either reduce the number of paperwork transactions made or offer a low level of support in terms of reports to production management.

A major difference in the application of functional staff was observed between the plants in the 'out of control' cases. The brake and clutch cases both used the traditional line and staff system, while the kitchen furniture case management relied on line management for these tasks. The differences in ratios of the various classes of employees were examined. This showed that the brakes case had just over a 4:1 ratio of total works employees to direct production operatives, while the kitchen furniture case had only a ratio of 1.9:1.

Table 13 Ratio of Production Directs to Total Employees ('Out of Control' Cases)

Case study	Production Directs	Prodn. Indirects etc.	Staff	Overall ratio
Brakes	39%	41%	22%	4.1:1
Clutches	26%	41%	33%	3.8:1
K.Furniture	54%	37%	9%	1.9:1

The low ratios of staff to direct production workers in the kitchen case affected the scope for the collection and analysis of data.

It can be seen from Table 13 that there was a major difference in approach in the level of staff between the sites. The comparatively low proportion of staff in the kitchen case arose from the strongly expressed concern of the Managing Director to maintain low overheads.

The argument has already been made that the manufacturing task in the three cases had grown more difficult to accomplish. This led to my considering what happened when there was an interaction between difficult tasks and low staff

ratios. The ability of staff groups to collect further data or to analyse existing data in more powerful ways was impaired by a combination of factors. The first factor working against the provision of better information was an increase in the number of transactions performed. In all three cases the product ranges had been increased and batch sizes reduced. As such changes had not been off-set either with changes to the processes, (i.e. from batch to flow or from systematic reductions in the number of documents per operation), there was an increase in the work load of staff. This phenomenon in the kitchen furniture case is shown below in Table 14.

Table 14 Volume of Transactions in a Two Year Period (Kitchen Case)

Number of transactions

Year	Customer Orders	Production Orders	Dispatch Notes
1984/5	19,416	est 270	3434
1985/6	42,916	est 350	6261

The second factor was that all three cases reduced their staffing levels to cut overhead costs. This further cut the time available for data collection and analysis. The lower ratio of staff in the kitchen case resulted in both the absence of important data and in the failure to perform important analyses on the transactional data. The Managing Director's routine information about production performance was limited to the stock availability report and the monthly accounts. No records were made of actual costs by product or specific departments, and thus the accounting data was limited to work study based standards of performance and total variances based on three monthly estimates or on twelve monthly audits. Information on costs was important as the product range grew, increasing the risk that variances in one product(s) would be hidden in the averaging of all products' costs.

5.323 Analysing transactional data for its strategic content

Records were not kept of the loss of material or labour incurred in rectification work, whether through faulty materials or from operator error. Yet the cost of sub-standard material was potentially high. An example of this occurred in the kitchen furniture case when the Managing Director insisted on the Purchasing Manager procuring cheaper material for one of the main product ranges. The Works Manager of the finishing plant was convinced that this material had led to low yields, but as no records were kept it proved impossible to confirm this. However, for the Managing Director this information should have been available for effective purchasing.

The kitchen furniture case also revealed that, of the information provided by staff, much was concerned with operational transactions. Nevertheless, such transactional data could have been analysed to provide early indications of breakdowns in the planned events. To demonstrate the value of this data I undertook a number of conventional analyses. As the main characteristic of the 'out of control' condition in this case was failure to deliver complete orders on time, I examined the transactional information and the single control system: the 'availability' report. Although the information on availability of finished stocks was not ideal, it contained potentially valuable information about which product types and sizes were most frequently out of stock. I analysed the records using the Pareto technique, discovering that over 82% of the stock outs fell in less than 19% of the range. While this was to be expected, the analysis also revealed that over 75% of the out of stock items were consistently on the list in a nine month period. This implied the need to revise the stock targets. Thus the critical information senior management needed in this situation was that acceptable delivery performance could not be achieved by production if they 'complied' with the control system limits set for them. The remedial action in the first instance was to revise the control system, and if this led to higher stock levels than was

economically justifiable, the correct course of action would have been to redesign the production system to make smaller stock levels a practical alternative. Thus control would be improved by changes in design of the processes and procedures, not in the reporting system.

Similarly some items were over stocked. This too would have been detected had suitable analyses been made. It was subsequently confirmed that the stock levels were set judgementally, as the Stock Controller did not either have a statistically based forecast of demand or make an analysis of the accuracy of the Sales Manager's predicted sales. However had senior management been informed of the level of failure to achieve delivery, they may have pursued the application of forecasting or inventory control techniques.

I tested the scope for producing reports from other transactional data, using a sample of the sales orders, in conjunction with the Sales Office Manager. This showed that the 'on-time' delivery performance had declined from 83.9% in October 1984 to 62.7% in September 1985. Examination of the records of 728 deliveries revealed a high level of part orders were being dispatched. For every 100 orders, 134 dispatches were required. This not only increased labour and transport costs, but also added to the number of paperwork transactions performed. Neither this information nor the costs involved had been reported to senior management. Further analysis showed that the largest selling range, believed by the Works Director to have the best customer service level, had in fact the worst service, at 73% compared with 77% for the other lines. It was discovered that (excluding accessories) 42% of the orders were for single items. The examination revealed that the average size of order delivered complete was 2.9 items against 7 items for the orders not delivered complete. Such information is strategically important for policy formulation and control both for production and other functions in the case. Subsequent checks confirmed that no allowance had been made for these effects in their control processes.

I therefore concluded that senior management in the kitchen case did not have the correct information and had consequently mis-identified some of their problems. As a result they were likely to seek the wrong solutions by applying their efforts in the wrong direction.

The Managing Director initially rejected the above evidence, claiming that the majority of orders were for larger numbers of items. A cross check using data drawn from a representative week's sample of customers was selected by the Sales Office Manager. When allowance was made for the number of accessories, the original findings were confirmed. The Accountant confirmed that the computer system suppliers had available packaged software which would provide the analysis shown above, and in addition they could supply a package which would forecast demand from the order entry data. Both of these controls were urgently required if the complexity of the manufacturing task was to be reduced to proportions that production management could currently handle effectively.

It was evident in the kitchen case that in some instances a number of problems could have been overcome by the greater use of analyses, but the Managing Director strongly opposed recruiting the additional staff needed. The heads of Accounting and Production Control and the Works Director all stated categorically that the Managing Director would not allow additional staff. Thus, they did not consider it worthwhile to request staff to perform additional analyses or collect the data.

While the failure to collect or analyse available data in the kitchen furniture case could be accounted for by the shortage of staff, the same could not be said of the brake case. Yet similar weaknesses occurred in the lack of analysis of senior management information. The KMT of quality was not well followed up by the reporting system. Using the production control records I found that for a 10 month period, covering a sample of 155 batches and 765,793 components, over 7%

of throughput was rejected, compared with a maximum allowance of 2%. This contributed to shortfalls in final assembly and was a major cost factor which was not highlighted to any level of management. Similar analysis of assembly records showed rejects ranging from >0.3% to 33%. This too was unreported. Analysis of the quality control records showed that patrol inspection identified that machines were outside the control limits (not specifications) on between 13% and 24% of occasions. This information was not circulated to management, nor was any Pareto type analysis made of either rejects or examples of non standard working practices. Similar non use of quality control records was found in the clutch case study.

5.324 Weaknesses in staff provision of information for the strategic review of production performance

Proposition
The information and analyses, provided to senior management by staff, fall short of that needed for the effective review of policies for production. In particular it fails to reveal important trends and patterns in perfomance.

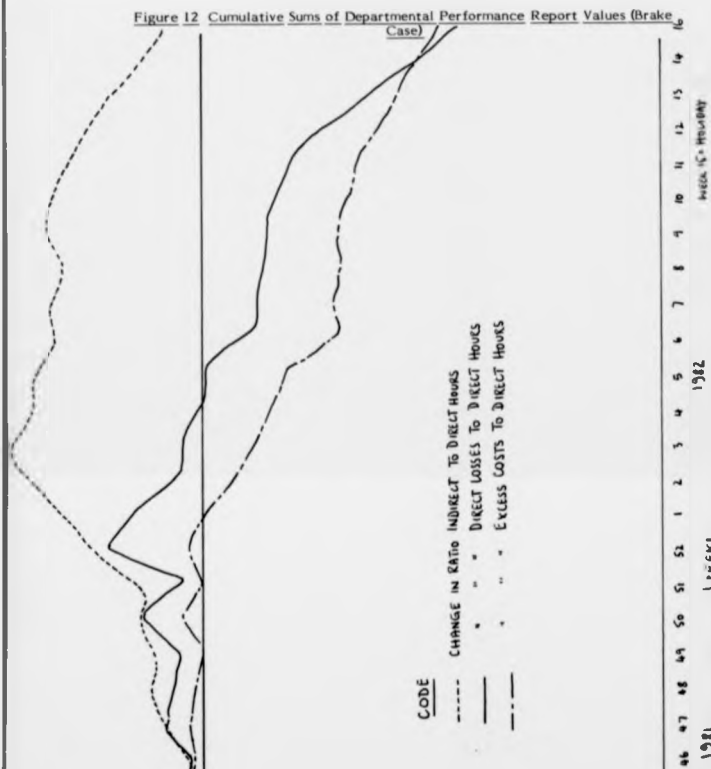
I showed above that senior management in the kitchen furniture and brake cases did not receive some strategically important information necessary to evaluate production's current performance. Similarly their information was weak in terms of data needed to reformulate policies to match changes in the competitive environment.

This led to consideration of the gaps in the information and analysis provided. I established that 72% of the reports received by the brake case Managing Director concerned daily or weekly levels of output. Interviews with the Heads of Production Engineering, Work Study, Administration (accounting) and Production Control showed that in all but the work study department they considered that it was the responsibility of the Managing Director or the Manufacturing Director, and not themselves, to request information if wanted. As a cross check on priorities, the heads of department were asked to identify their perceptions of the KMTs. The heads of department, again with the exception of work study and

to some extent production engineering, identified lower manufacturing costs and improved quality. The fit between their priorities and those of the Managing Director was weak. This was considered the main reason for the non provision of the strategic information.

The brake and kitchen furniture cases both revealed a tendency, in a number of the reports, to present information to senior management in over simplified formats. These were unsuitable for more than a visual review of the contents. No examination of trends was made, even at the elementary level of moving averages. An example of simple trends and CUSUMS is given below in Figure 12. The 'cumulative sum techniques' were unknown to those producing the reports. This revised form of presentation revealed changes in the pattern of labour utilization which were not evident in the conventional form of presentation.

Figure 12 Cumulative Sums of Departmental Performance Report Values (Brake Case)



The graph in Figure 12 demonstrates that there were improvements in all three dimensions of labour performance. The reduction in the level of losses in 'direct hours' and of excess costs in 'direct hours' was shown to start in week 1, while those of the ratio of 'indirect' to 'direct hours' did not start until week 4. The CUSUM technique identifies such changes more rapidly than other methods. It has already been shown that in the brake case the total factory labour hours were known by type for all the group's plants. The data was only presented as simple numbers and graphs.

5.323 Adjusting staff analyses and information to match changing manufacturing tasks

Proposition
The information provided to senior management by staff about production performance fails to reflect adjustments to production's manufacturing tasks.

As noted above, the mis-match between the manufacturing task and the process design was a major cause of the 'out of control' condition in the brake case. This could not be rectified simply by the provision of better control information or analyses of failures to meet the performance levels set for production. The changes in the manufacturing task required of production to meet the increased competition faced by the firms was not paralleled by changes in the staff provision of information to senior management.

I noted above that the brake case had changed from making a small range of high volume products to a wide variety of products. There was also a new emphasis on service sector products. Staff, particularly production engineers, were responsible for developing new manufacturing processes to improve the controllability of the plant, while production management was responsible for implementing these changes. The staff did not, however, either provide the Managing Director or the Manufacturing Director with analyses or introduce control reports which would have reflected the complexity arising from the widening product range. This was particularly noticeable in terms of the addit-

ional changeover associated with the wider product range. This change in the manufacturing task was not matched by quicker setup times, or closer control of setter time, nor was it supported by revisions to the information or analyses provided by the staff groups. Yet, at the time of the study, Setters represented 21% of the blue collar workforce. Despite this, neither production engineering nor work study undertook any schemes to reduce the setup times. Investigations showed that both functions believed that they were not required to make improvements to the performance in this area. The Chief Production Engineer claimed that the problem needed to be solved by purchasing new CNC machines, with quicker setup capabilities. They considered the priority for improvements was in reducing the 'running time' of processes. They explained this response stating that they were required to produce a £250,000 cost saving p.a. and that savings from quicker changeovers did not count as part of the target. The Group Manufacturing Director rejected that interpretation of his instruction.

Additionally, the Production Engineers applied the full 700% factory overhead rate to the time saved on shopfloor activities. While this is undoubtedly an element of overhead which needs to be recovered on changeover times, using the rate applicable to production was arbitrary and therefore possibly misleading. The reduction or removal of the job it was allocated to, only resulted in the costs having to be recovered on the tasks. The new more flexible machinery was considered by the Manufacturing Director to be necessary in order to achieve high product specifications. The Production Engineer confirmed that his staff worked on the reduction of cycle times and not setup times as the latter were part of the overhead, and thus did not count as part of the required cost saving programme. Staff in the different functions within the brake case differed significantly in their provision of analyses of underlying problems.

Despite the general pattern of staff failure to adjust their roles to suit changing manufacturing tasks, some exceptions occurred. The Production

Engineers produced reports from investigations into long standing problems. In one example they suggested ways in which labour losses on assembly could be reduced from 42% to 20%, redesigned the assembly line to reflect a lower level of demand and suggested ways of reducing rejection levels. Thus the function clearly had a reasonable level of professional staff who could undertake such exercises. Similarly, work study carried out a number of investigations, often as a result of a request from the Production Manager.

It was, nevertheless, evident that the system did not as a whole lead to an integrated attack on the problems faced by production management. Some departments, notably work study, attempted in part to reduce the existing level of complexity, others, namely, quality control, production control and production engineering did not. The latter sought technolgical changes, such as new CNC machines, which would have had some impact on the complexity caused by the long setup times combined with small batch quantities. In the clutch case, staff tended to provide less analyses than in the brake case. There was, however, a similar tendency for the reports to reflect old rather than current priorities. In particular, the emphasis on direct labour control appeared mis-matched with their level at 4% of works costs.

5.326 The mis-match between staff efforts to control and corporate needs

The research has shown that while senior managers expect both line and staff to play important roles in controlling production, the nature of their roles differs in important ways. In particular the line managers role in control is achieving compliance, while that of the staff manager is in designing and operating controls.

The intensity with which staff play this role was shown to differ significantly. In the brakes case a full range of staff services was provided, while in the kitchen furniture case the policy of limiting staff numbers meant that only a limited

service was available. It was noted that staff in both cases tended to meet the transactional requirements of the manufacturing system before producing the control reports for senior and operations managers. Thus, where few staff existed, the impact on the provision of information was acute.

It was further noted that the priorities of the staff functions tended to lag behind the changing arenas of manufacturing competition. Thus, where control reports were received there was a danger of a mis-match between them and the latest KMTs / OWC.

The final weakness that was detected was that of a failure by staff groups to come to grips with the basic causes of any loss of control. While there were some limited attempts to reduce the complexity of the manufacturing systems, there was very little recognition by them that attacking the causes of uncertainty was a critical component of achieving control.

5.4 WEAKNESSES IN PRODUCTION MANAGEMENTS' CONTROL OF PERFORMANCE

It was shown above that senior management in the 'out of control' cases did not exercise effective control over the performance of their production functions. It was also apparent that the staff functions, where they existed, did little to assist senior management in terms of revising their reports to match changes in the manufacturing task. This section focuses on the weaknesses in the control of production performance by production management.

5.41 Comparing Production Managements' Written Control Information with the Firms' Competitive Goals

Proposition
The routine written reports received by production managers are weakly linked with the companies' main competitive goals.

The written controls were weakly linked to the way the firms sought to compete. Secondly, the primary emphasis was on workflow followed by control of

labour efficiency. The written reports were frequently only used to 'confirm' information already known to the Production Managers. The reports were frequently used as a means of checking the accuracy of what was reported about production rather than as the basis to take corrective action for Production Managers. The Production Managers needed rapid feedback which the written reports largely failed to satisfy. These reports were also heavily oriented to results rather than to the behaviour or processes involved. Such information fell short of that needed to achieve effective control of production performance. In an attempt to overcome these weaknesses, more immediate and process oriented information was gathered by the Production Managers themselves using patrols of the shopfloor, making personal contacts and collecting raw data from various sources.

A comparison was made between the Managing Director's KMTs, and the reports he received. This revealed a mis-match, of which the principal points are shown in Table 15 below.

Table 14 Comparison of KMTs and Weaknesses of Written Information (Brake Case)

Aspects of competition relevant to manager	Reports received	Comments
Reduce lead time to introduce new designs into production	Minutes of committees	All items to be produced and recorded against individual responsible with dates for completion. System worked well at this level but lacks a means of identifying the critical path - or sequence of jobs necessary to minimize time. Similarly, no account of conflict of resources is possible other than from the judgements of individuals concerned
Minimize tooling costs	Single special	The tool making facility was under the jurisdiction of the Chief Production Engineer and thus the Manufacturing Study Manager's control was indirect There were no controls in use, although one special study had been ordered by the Group Manufacturing Director. This revealed their costs to be higher than in the group's European plants.
Two other reports received close attention from the Manufacturing Manager. These are as follows:		
Production output levels	Weekly statement	Important information in the reports was not analysed. Evidence of uneven levels of output achievement (storming) was ignored. It needed redesign to show the output required in remaining weeks and capacity to prompt more rapid action in early weeks of month.
Overtime	Weekly overtime report	Closely monitored from report and with wall graph. However, evidence of unreliable information on work available, resulting in weekend working followed by idle capacity on the Monday morning with component shortages.

Similar weaknesses occurred between the Production Manager's information and the plant's KMTs. The main points were that cost variances were global rather than for individual products. With a wide variety of products and a considerable difference in their complexity of design and tolerance limits, there was a serious risk of uneven levels of variances between products.

Given a failure to achieve the desired level of output for original equipment and service products, despite the notionally excess capacity, it was considered important that more reliable planning and monitoring systems be developed so that this critical aspect of performance would be improved. The Production Manager also needed to monitor progress on meeting the plant load.

Similar weak linkages were noted between the information in written reports and the competitive goals in the other instances of 'out of control'.

5.42 Production Managers' Primary Concern with Information about Work Flow Transactions and Labour Efficiency

Proposition
The two main sources of production management information are meetings and reports. Both sources emphasise work flow transactions and, to a lesser extent, labour efficiency, rather than the wider control of production performance.

Table 16 shows the results of the questionnaires about the Production Managers' and Supervisors' preferred sources of information.

Table 16 Ranking of Managers' Preferred Sources of Information

PREFERRED SOURCES OF INFORMATION	CASE STUDIES BRAKES	CLUTCH (Assy. Supervisor only)	KITCHEN FURNITURE	AVERAGE
PRODUCTION MGT'S OWN SOURCES				
Production meetings	1	1	1	1
Personal contacts	3	2	4	3
Touring the plant	3	3	3	3
STAFF BASED SOURCES				
Written reports	2	4	2	2.67
Non-production meetings	5	5	N.A.	5

I compared the examination of the Production Managers' preferred sources of information with those of the 'in control' cases shown in section 4. The results are shown below in Table 17.

Table 17 Differences in the Pattern of Preferred Sources of Information

Information sources	'In Control'	'Out of Control'
Personal contacts	1	3
Production meetings	2	1
Touring the plant	4	3
Written reports	3	2
Non-production meetings	5	5

The comparison was made on very limited evidence (six cases). However, it suggests that managers in the 'out of control' cases relied less on personal contacts and more on written reports and meetings. While this conclusion must be treated with caution, it is consistent with the greater reliance on formal means of control to overcome the problems found in the 'out of control' condition. However, as suggested in section 4, the informal sources and collection of own data tended to give information that revealed the behaviour of the systems of production as well as their immediate tangible results.

Table 17 shows that the two main sources of information were their own meetings and written reports. The latter were, however, considered only marginally more important than other sources of information. Examination of both of these sources of information showed that they primarily concentrated on the regulation of workflow. This was emphasised in ways which were disproportionate to the way the firms competed in the market.

5.421 The emphasis in the written reports

Proposition
The reports received by production managers concentrate on output and labour efficiency and provide little coverage of the wider ranges of ways in which production can contribute to competitiveness.

I examined the relative frequency of the Manufacturing Manager's control reports in the brake case, repeating the method as in section 4. The findings

were compared with the average of the 'in control' case studies. The results of this comparison are shown below as Figure 13.

Figure 13 Number of Reports in Four Week Period by Manufacturing Manager (Brake Case) Compared with Average of the 'In Control' Cases

Category of Performance	Brake case % of reports	Average in 'in control' cases
Output quantities	64	36
Labour performance	26	6
Sales performance	6	13
Introduction ofnew products	4	4
Financial / cost	2	4
Other	0	36
Total percentage	100	100
Total number of reports	110	144

N.B. The comparison of the 'out of control' cases was limited to the brake case because of the very small number of reports in the kitchen furniture case.

The largest proportion of reports, in both the 'in' and 'out of control' cases, was devoted to output figures. It can also be seen that two other categories showed significant differences, namely labour performance and 'other'. There was a much greater emphasis on labour performance in the 'out of control' case. The general category 'other' reflects the interest in the 'in control' cases in plant utilization, plant load and inventory levels.

It would be simplistic to expect a very close correspondence between the frequency of reports and the KMTs. However, I considered that the proportion of reports dealing with output and labour was likely to distract attention from other important aspects of performance. In this instance, the emphasis on output and production labour was likely to hide the need for improvements to quality, reduction of inventories and lead times. Further the immediacy associated with output reports might encourage a shorter rather than longer term approach to problem solving. Thus, any disposition that might exist towards fire-fighting was likely to be re-inforced.

Similar reviews were made of the reports received by the Production Managers and Foremen in the brake case and the Superintendent in the clutch case. These also reflected an emphasis on output and labour. However, in the brake case, the Production Manager received information on the utilization of selected pieces of plant. While less pronounced in the kitchen furniture case, a similar bias towards output data was observed.

5.422 The quality of the link between production managers' reports and the KMTs, in the 'out of control' cases.

I repeated the form of analysis, of the quality of the linkage between the control reports and the KMTs, shown in section 4 above. The objectives were two fold. The first was to evaluate the relevance of the reports to the KMTs / OWC, and the second was to consider the usefulness of the reports in achieving their aims, even where those aims were not closely linked with the competitive priorities of their firms. The result of the analysis is shown below in Table 18.

Table 18 The Quality of Fit between Reports Received by Production Managers and their Plant's KMTs/OWC

	DIMENSIONS OF PERFORM-ANCE	BRAKES MD's Priority	BRAKES Evaluation	KITCHEN MD's Priority	KITCHEN Evaluation
(1) Measures of Customer Service	Delivery	A	5*	A	4
	Flexibility	B	5*	C	5*
	Cost	A	3	A	4
	Quality	A	4	A	4
	Sub-score	1.25	4.25	1.50	4.50
(2) Measures of Resource Efficiency	Labour Prod-uctivity	B	2/3	B	4
	Machine Utiliz-ation	D	5*	D	5*
	Inventory	B	4	C	4
	Quality costs	B	4	C	5*
	Sub-score	2.50	3.88	3.00	4.50

(Scoring system: Evaluation of reports: 1 = Excellent, 2 = Very good, 3 = Fair, 4 = Weak, 5 = Poor. Priority of performance: A = Essential, B = Very important, C = Important, D = Slightly important, E = Unimportant)

(*) No report received

Table 18 raises a number of important issues. Firstly, it shows that senior management, in the 'out of control' cases, did not follow the concepts of manufacturing strategists, who claim that production cannot simultaneously do well on all dimensions of performance. Instead, although 'out of control', they expected production to achieve 'excellent' performance in all three classical areas of performance: costs, quality and delivery. Additionally, in the brake case, production was required to achieve 'very good' flexibility. Simultaneously, meeting all the above goals would be difficult for world class competitors, but for plants that were 'out of control', seeking excellence in such a wide variety of areas was likely to worsen rather than improve performance. This could occur if production management, finding it could not do everything, switched from issue to issue or made erroneous judgements about the trade-offs required between the different aspects of performance.

Secondly, in contrast to the stated wide range of performance criteria discussed above, Table 18 shows that only a few dimensions of performance were closely monitored. Two interpretations of this phenomenon are possible. Either senior management overstated the importance of the wide range of areas of performance or they failed to monitor important aspects of performance. I concluded that the weight of the evidence suggested that the latter was more prominent than the former. I did so because in two areas of performance, delivery and quality, both the main 'out of control' cases' performance noticeably fell short of expectations. I have previously shown, when examining the transactional data in these cases, that:

(a) 37% of orders in the kitchen case were not delivered on time. In practice performance was worse than this, as the majority of late deliveries were for larger order sizes.

(b) output in the brake case was approximately 18% below target

(c) internal quality levels in the brake case were worse than allowed for at 7% of production, instead of the maximum allowance of 2% in the costing and scheduling systems.

The need for information about delivery performance could not adequately be satisfied by the kitchen case's 'availability report', as it did not consider orders, but rather it showed what was in stock. While it is possible that part of the gap between the content of the reports and the production managers' requirements could have been filled by managers using their subjective knowledge and understanding, it is unlikely that it would have provided a satisfactory basis for control. Although not wanting to understate the value of such knowledge and judgement, it is nevertheless necessary to be cautious about its quality, particularly where there is a wide product range and therefore much diversity.

Similarly, weaknesses in information about quality was considered significant. Production managers in the brake, but not the kitchen furniture case, received data on scrap levels. The latter did, however, receive a monthly summary of customer complaints. This was a new document which was only started after I interviewed the Marketing and Managing Directors and asked how they knew about quality performance. Initially, production was only told about the financial value of the customer complaints. Later, this was changed so that they saw the items when available or the letters where not. What they did not know was the level of rejects or re-work conducted in the plants. With a natural material such as timber, the scope for minor re-work is great and thus requires to be known. This is particularly relevant given the pressure by the Managing Director to purchase cheaper timber. It was unexaminable, however, as no records were kept of production times etc.

A comparison was made between the results of the above analysis for the 'out of control' and the 'in control' cases. I aggregated the evidence into two categories: 'customer service' and 'resource efficiency'. The result of the analysis is shown below as Table 19.

Table 19 A Comparison of Customer Service & Resource Efficiency in 'Out of Control' & 'In Control' Case Studies

	'In Control' Cases		'Out of Control' Cases	
Performance Criteria	MD's Goal	Research Score	MD's Goal	Research Score
Customer service	1.5	3.6	1.4	4.4
Resource efficiency	2.7	2.9	2.8	4.1

N.B. The score shown is my evaluation of the quality of the reports.
(Evaluation scale: 1 = high; 5 = low)

The Table shows that a marginally greater importance was placed on customer service dimensions of performance in the 'out of control' cases (1.4) than for the 'in control' cases (1.5). It also shows that the quality of the reports was significantly worse, in these 'out of control' cases, at 4.4 compared with 3.6 for the 'in control caes. The reason for the higher score on importance of customer service was the wider range of items regarded as 'essential'. Table 19 shows that instead of focusing attention on a few critical issues, senior management in the 'out of control' cases operated a wide rather than narrow set of priorities. This wide range suggests that senior management was reacting to the 'out of control' performance in these cases by seeking improvements on many, rather than a few critical, dimensions of performance. This was consistent with the earlier evidence that they did not have manufacturing strategies or statements of their key manufacturing tasks. The Table also shows that the quality of the reports about 'resource efficiency' was less good than in the 'in control' cases. This led me to consider the production management's other sources of information to see whether they overcame the limitations of the written reporting systems.

5.423 The emphasis in the production meetings

Proposition
Where production management meetings took place they were dominated by attention to expediting workflow rather than the elimination of recurring problems in the production system.

It was shown above that production management and supervision in the 'out of control' cases considered their own meetings to be their most important sources of control information. The examination was limited to the brake case as no formal meetings were held by production in the kitchen furniture case.

Production in the brake case made extensive use of scheduled meetings These ranged from an average of 8 hours a week for the Manufacturing Manager, 12 hours for the Production Manager, and 13.5 hours for the Superintendents and General Foremen. Additionally a number of unscheduled meetings and many 'discussions' occurred in the corridors. The high incidence of meetings in this case was examined to identify their content and role in control.

Two separate morning meetings were held, one each for the two major divisions of the plant. The meetings were chaired either by the Production Manager or, less frequently, a Production Superintendent. On average, fourteen managers, superintendents, foremen and staff attended the morning meetings, consuming 52.5 managerial hours per week per division, 105 hours for the plant. Analysis of the time devoted to each topic and their style of organisation showed that the meetings concentrated on expediting items from a list compiled by the Production Manager, rather than on resolving problems, or ensuring that the wider issues of competitiveness identified by senior management, were achieved. The content and conduct of the meetings were examined to identify their effect on the control of production.

The tenor in which the meeting was conducted was considered significant. This is demonstrated by a quote from the Production Manager at the end of one meeting approaching the period end.

> "Yesterday was a sheer ..... disaster. We will have to tear this place apart to get the maximum output."

Such views were forcefully expressed on a number of occasions. The meetings generally started and finished with the Production Manager rebuking the Foremen and Production Controllers for the shortfalls in previous day's output. In the final weeks of production periods, direct workers were moved from the early stages of production into assembly areas to 'boost' output. The emphasis on

expediting and a tendency to storm the month-end, increased the uncertainty and complexity already existing due to the mis-match between the highly dedicated production technology and the changing pattern of order sizes and different means of competing in the market. The conduct of the meetings also demonstrated the need for basic training in such skills as chairmanship and the management of time.

While the above reflects what took place at the meetings, it has not shown a number of significant omissions. The first omission was the absence of attempts to smooth output levels and steadily overcome production difficulties. Such an approach was needed to counter the effects of the process - task mis-match. No analysis was made or discussed at these meetings to solve bottlenecks. A second omission concerned the failure to discuss the control of changeover times. The wide product range and frequent rescheduling of jobs made setups a critical factor. Not only was there no improvement in the setup performance, but the times were not even recorded. Similarly, scope existed for improving the proportion of setups passing first-off inspection, first time. Yet this was not discussed. These omissions reflected that production management in the brake case was more concerned with fire-fighting than resolving the causes of its problems.

Another effect of the large number of meetings was to reduce the time available to exercise control through observation on the shopfloor. I showed this by counting the number of workers walking along the passageways, both when the meetings were, and were not, taking place. I compared the results and over three separate trials, this showed 45% more workers in the gangways when the Foremen were absent. This suggested that the meetings indirectly contributed to the loss of control. I discussed the finding with one of the Superintendents. His cross check of the situation confirmed the conclusion. He then arranged to cut short some of the morning meetings to 'get the Foremen back on the shop floor'.

Despite the high ranking given to meetings in the kitchen furniture case, formal meetings in the plants were very rarely held. However, the Works Manager in the main factory used the morning and afternoon coffee breaks to meet his Supervisors and to exchange information with them. The Assembly Superintendent in the clutch case attended the Production Manager's daily meetings, but refused to hold meetings of his own, despite instructions to do so from the Production Manager. He explained that he was 'too busy' (chasing up late items) to have meetings. Despite these wide differences in time and formality in the different cases, meetings were seen as a primary means of production management information in all three cases.

Although meetings were reported as an important source of information, it is evident that they were primarily used to expedite output, particularly as month ends approached. Thus they contributed to uneven levels of activity in the production period. They were also shown to be ineffective vehicles for solving problems, such as the control of setup times. In addition there were indications of a lack of control on the shopfloor during the meetings. I also considered that had such meetings been conducted effectively, senior management would have had greater scope for delegative decision making to production management and thus freed themselves to give greater attention to strategic issues. Given the substantial time consumed in their attendance and low effectiveness, particularly in the brake case, the managers' high valuation of meetings appeared to be inflated.

5.43 The Non Workflow Control of Production Performance

Proposition
The control of the non workflow dimensions of performance is predominantly achieved by production managers' use of direct information gathering methods, rather than from reports.

Although the questionnaires showed that the production management teams in the 'out of control' cases placed less priority on information from their own sources, than did their counterparts in 'in control' cases, they remained an important source of information. Production Managers were observed to use a

number of direct means of obtaining the information they required to accomplish control. These included patrolling the shopfloor, use of personal contacts and collecting raw data from the shopfloor. I interviewed the managers, who suggested that they used these methods because of the rapid access they gave to information. They also claimed to have more 'trust' in such information, than in the written reports. The contradiction implicit in the statement by the production managers that they preferred the written reports to the data they collected, was not consistent with their own declared 'lack of trust' in the written information.

5.431 Use of shop floor patrols

Production Managers and Foremen in the clutch and kitchen furniture cases regularly patrolled the shop floor. Although the Supervisors in the brake case gave this source of information the same rating, they appeared to spend less time on the shop floor, than those in the other two cases. This could, in part, be traced to the average of 13.5 hours per week they spent in meetings.

The Works Director and Works Manager in the kitchen furniture case were both observed to use these shop floor patrols to test product quality and to identify worker attitudes. I accompanied the respective managers on a number of occasions when they toured the plant. It was noted that they ran their hands over the surface of the stacked products as they went past them. When they considered the surface unsatisfactory they stopped and made a more formal inspection of the products. It was also noted that as they stopped to talk to the various workers they generally asked how the worker was, rather than how the job was proceeding. The workers, on the other hand, generally gave a dual response, reporting the progress of the work and their own state of health or feelings at the time. When discussing this behaviour with the managers they initially expressed surprise that they had behaved in these ways. However, as they reflected on

their own conduct, they both expressed the view that both parts of the behaviour enabled them to either identify existing quality or anticipate future quality levels. In these discussions a number of the Production Managers volunteered the view that the patrols gave junior supervisors a chance to inform them of any actual or anticipated hold ups in the workflow.

In the clutch case the Production and the General Managers both said they regularly conducted tours of the plant with the Assembly Superintendent to guide him how to observe what was taking place in his department. Both said that they considered such observations an essential source of information.

In the discussions following up these questionnaires, there was general agreement that the patrols were primarily orientated to detecting errors or deviations from agreed systems of working. I probed the Managers / Foremen concerned to try and identify whether they used these patrols as a basis for seeking improvement. Although all said they did, not one was able to offer a specific example of improvement that came from patrolling the shopfloor. All the examples quoted referred to detecting incidents where unplanned behaviour was occurring. I concluded that although an important source of information, the 'tours' provided a backup, rather than a major direct means of control.

5.432 Use of personal contacts

As noted in section 4 above, this source of information was not followed up because of its probable impact on the method of study required. However, the following points were noted when pursuing other aspects of the investigation. Most supervisors rated the use of personal contacts as equally valuable to data from their patrols of the shopfloor. While this form of information gathering was difficult to record, it was clear from their discussions that for most of them it was an accepted source of information. These discussions showed that the

information thus obtained was primarily used to provide 'early warnings' of impending difficulties. This came from operatives, setters etc. advising them of actual / potential problems. Only in two incidents did the Foremen discuss using personal contacts outside the shopfloor. In these incidents the contacts were production control warning them of changes due to occur in the planned work load.

5.433 The collection of raw data by Production Managers

I showed above that the Production Managers in the 'in control' cases collected their own data to overcome the delays in the written reports. This behaviour was repeated in the 'out of control' cases.

Table 20 Comparison of Time to Obtain Information: Direct v. Formal Systems (Brake Case)

ASPECT OF PERFORMANCE	HOW SUPERVISORS OBTAINED THE INFORMATION AND WHEN	TIME FOR FORMAL REPORTING
Production levels	Own section - chargehands prior to Morning Meeting Other sections (feeders) - Morning Meeting Attendance 0.5 hours after shift start	1-3 days
Attendance & idle time	None	10-14 days 10-14 days
Scrap / reject levels	Rejection slips (next working day)	14 days

Production Managers in the brake and kitchen furniture cases made extensive use of personally collected raw data. In the brake case this included information about worker lateness and absenteeism. To control output the Foremen needed to know each day how many workers were available and thus which lines could be manned. The written reports on lateness and absence, however, arrived 10-14 days later. To overcome this deficiency the Foremen collected all 'unclocked'

cards within half an hour of each shift. Workers who were late had to ask for their clock cards from their Foreman. The rapid access to the information enabled them to reallocate labour to meet the latest 'emergency' in the workflow. Similarly, a number of brake case Foremen also collected the previous day's rejection slips from inspection. The written report on the cost of rejects did not arrive until 14 days later, and although these reports did provide cost information, most of the Foremen were familiar with the general level of cost of the various items made in their sections. Thus, they were able to take corrective action much earlier than they would have done using the existing written reports.

A distinction needs to be made between the use of raw data in the brake and kitchen furniture cases. The Foremen in the brake case used this source of data to give more rapid information about performance than was obtained from the reports. The Foremen and Manager in the kitchen case used the same approach. However, in their situation, they did so to obtain information that was not otherwise available as reports. The low level of documentation in the kitchen case reduced the scope for monitoring from this source. Instead the Production Manager was observed to spend time checking the settings on machines, the accuracy of scales etc.

The discussions with production management in the brake and kitchen cases showed that they were surprised that the collection of raw data was considered part of the control processes. They said that it was a 'natural' part of their job, which they 'just did, rather than thought about'. However, there was almost universal agreement that it gave essential information about the working of the plant. Examination of the data collected showed that it was frequently concerned with the behaviour of the production system, rather than the results that were being accomplished. As such it reflected in part the reported practices of Japanese production management.

5.44 Production Management's Approach to Control

We have seen in these cases that some important data was not collected while other important data was not used effectively; also that insufficient analyses were made of the available data. While these weaknesses contributed to the 'out of control' condition, they did not fully account for the failure to achieve control. The following sections examine other positive and negative influences and their effects on the loss of control. Four major issues are considered. Firstly, linked with the concentration on output levels, was a tendency to storm the month-end output; secondly, was production managements' narrow view of their role; thirdly, was their lack of commitment to improving the underlying manufacturing processes outside the narrow area of labour efficiency; finally, was the low level of training and updating of their skills.

5.441 Month end storming

Production, in the brake case, was dominated by month end storming of output levels. To assess the extent to which it occurred, I examined six months output figures for seven product groups. In level production the output in all weeks would be approximately even. Thus storming could be measured by the difference in the output of the last over first weeks of each month. I also checked whether storming applied equally to original equipment and service products. Data was taken from the 'Weekly & Monthly Output' report of the period week 40, 1981 to week 17, 1982. The results are shown below in Figure 14.

Figure 14 Degree of Month End Output Storming in Original Equipment and Service Parts in the Brake Case Study

	Product Group	Month end / month beginning output		
Original Equipment Products			Service Products	
	A	16.2 %	D	140.5 %
	B	41.7 %	E	85.6 %
	C	-6.9 %	G	199.9 %
Unweighted Average		17.0 %		133.7 %

Figure 14 shows the difference in the level of output between the final and first weeks in a production period. Thus, it can be seen that for original equipment products output was on average 17% higher in the final week than in the first week, while for service parts the difference was greater at 134%. This shows strong evidence of month end storming of output. The storming was significantly greater for the more profitable service products, than for original equipment parts. The uneven level of output was likely to reduce the total monthly output compared with that achieved if an even level of production had been maintained, unless overtime was worked or additional effort expended to make up for the time lost in the slack periods. It should be noted that items F & G made part of the end (original equipment) product C. It can be seen that preference was given to service parts at the month end, adversely affecting the output of the original equipment product. This suggested that the service parts were provided at the cost of delivery to original equipment customers. The Foremen responsible for producing these parts confirmed that preference was given to 'high earning' service sales.

Further examination of the same six months data revealed that output regularly fell short of the planned targets, achieving only 82% of scheduled production. This did not in practice mean a worsening delivery performance, as the target was based on over production to eliminate the backlog in demand.

In the kitchen furniture case, the Works Managers were concerned to achieve the level of output needed to recover the financial target set in terms of contribution. Thus they urged their plants to complete orders when nearing the month end so that the target was met. Although the Managers said that they would not delay a low value product that was in back order, in order to complete a higher value item that was not, they both agreed that where other factors were equal, high value items were sent to stores at month end in preference to lower value items. This was regardless of whether there was a customer for the items

concerned.

The Managers in the brake and kitchen furniture cases were reluctant to discuss the relative importance of output levels and product mix. However, both informally confirmed that output levels came before meeting a schedule from the stockholding function. These perspectives, while understandable, were likely, in the absence of clear measures of delivery performance, to distort production performance in favour of uneven output levels and thus encourage fire-fighting through the lack of smooth well developed approaches to achieving the required level of output.

The definition of 'acceptable delivery performance' had received little recognition in any of the cases. In the clutch case an informal definition of 90-95% was commonly discussed but lacked an operational definition. Thus, they had not determined whether this meant 90-95% of orders met ex-stock or 90-95% of parts delivered ex-stock.

It can be seen, therefore, that the combination of month end storming to meet production targets and the lack of control information on delivery performance were in complete contrast with the basic principles behind Japanese manufacturing systems. There could be no greater contrast than between level and stormed output and between great attention to delivery performance and its non-recording. It is therefore not surprising that the states of control achieved in these two approaches differ so remarkably.

5.442 Production managements' narrow view of their role

It has been shown above that attempts to achieve the target output tended to dominate the Production Managers' approaches in the 'out of control' cases. An important secondary factor was the reduction of production direct and indirect

workers. The concern with output was understandable, as in all three cases it fell short of the targets. In the kitchen case the shortfall was overcome towards the end of the research when they changed the system as a consequence of discussions with me. Where there was a choice of several different finishes to the same product, the system was changed from holding all the finished stock as separate items, to holding a week's supply as finished items and the remainder as common stock. These were then finished in the appropriate colours as demand arose. This easing of the back order situation resulted in senior management putting a new emphasis on the importance of quality.

Discussions with production managers in these cases and observations of their practices showed that they had a restricted view of their role in their firm's competitiveness. This was most easily detected in their approach to the wide variety of products they needed to produce and the associated inventory levels. In each case these wide product ranges were combined with corporate competitiveness based on achieving low costs. One component of lower costs was the level of inventory, particularly 'work in progress'. In all three cases senior management had caused the inventory levels to be cut or reduced in comparison with the activity levels. Yet, in none of these cases did production management actively seek to positively reduce the stock levels or to actively manage the changeover times which would have facilitated the production of smaller batches. In the brake and clutch cases, where there was documentation from the quality control functions, this information was not used to examine the behaviour of the manufacturing processes used.

5.443 Lack of learning about process behaviour to achieve improved performance

I considered the failure to use information about the behaviour of the processes to be significant. This was particularly noticeable in the brake case, where detailed inspection records were available, which showed major departures

from planned quality levels. Although these variations did not always lead to rejects, they showed that the processes were not in a statistical state of control.

The lack of a state of control in the brake case was shown both in the quality control records and in the transaction data on setups. A large proportion of setups was rejected at the first-off stage. Although recorded, this did not form part of any management report. Analysis showed that in excess of 25% of setups on the automatics were rejected at first-off stage. The ratio on nights was higher. Similar analyses on other machines revealed first-off rejections ranging from zero to 75%, with an average of 32%. Not only does this inevitably lengthen the changeover times, it also indicates a lack of competence by the Setters and a lack of control by production supervision. The quality control records were similarly not used effectively to learn about the behaviour of the process. I reviewed these records and established the results shown in Table 21 below.

Table 21 Analysis of the Inspection Records of a Department (Brake Case)

TYPE OF MACHINE	No. OF TESTED	1st. OFFS REJECTED	% RE-JECTED	No. OF PATROL VISITS	No. OF TIMES M/C STOPPED	% STOPPED
DEIDESHIEM	11	8	73%	307	197	[illegible]
WICKMAN	12	6	50%	N.A.	N.A.	-
SCHUTTI	6	3	50%	N.A.	N.A.	-
L.S.A.	9	2	22%	210	63	30%
WAVIS	20	3	15%	31	7	23%
GNUTTI	18	1	6%	107	17	16%
MILLER	18	1	6%	113	3	3%
PLUNGE GRINDER	1	0	71%	76	34	45%

The above table clearly demonstrates that some of the processes were not effectively under control. It was precisely in this area of mastery of the technical processes that the German and Japanese systems of production management achieve their advantage.

5.444 Training and updating of production management skills

Section 4 discussed the German and Japanese approaches to management training in the 'in control' case studies.

The wide differences in approach, noted earlier, between the brake and kitchen cases, were also evident in their view of training. In the brake case all Supervisors were given management training at the group's training centre. This training was recognized by the National Board for Supervisory Studies as an exempting qualification. Thus, such training was relatively rigorous. Such an approach reflected the size of the group and of the plant, which had over 2000 employees on that site alone. The kitchen furniture case was at the other end of the training spectrum. Only one of the Supervisors or Managers had any training and that was one week. Yet none of the Foremen level personnel considered they needed any training. Indeed the one Supervisor who had been trained said, "I've had my one week, I don't think there is anything else I need to know."

Although the Supervisors in the brake case had, by comparison, good basic management training, in neither this, nor in the other 'out of control' cases, was there any systematic training or updating of the technical skills needed to master the production process. In this sense they fell well short of the German and Japanese approaches. As part of the interviews all Supervisors were asked if they wanted any form of additional training to enable them to achieve better performance. Only one General Foreman in the brake case and none in the kitchen furniture case considered this necessary. The Works Director and the Works Manager in the kitchen furniture case both wished to undergo a course of training. In neither instance had they any previous management or technical training other than an apprenticeship for the Works Manager.

The lack of concern with learning and continuing improvement was a charact-

eristic of the 'out of control' cases. While they all expressed the desire to be in control, their concept of control was, almost universally, to return to the 'steady state' model of control.

5.5 CONCLUSIONS ABOUT THE 'OUT OF CONTROL' CASE STUDIES

I showed above that the 'out of control' and 'in control' case studies applied essentially the same approach to controlling production. Both, to greater or lesser extents, adopted the traditional paradigm; seeking to achieve / maintain stability within evolving environments. In both instances the aim of stability became too closely associated with static performances, when changes were required to meet evolving market places.

Senior managements' approach to control at the macro and micro levels was a significant factor in the loss of control. The macro level combination of seeking improvement to corporate competitiveness via better manufacturing and the failure to develop manufacturing strategies, was significant. It led to increased product ranges and widening sets of performance criteria, and in turn to greater complexity and increased difficulty in the management task. Instead of recognizing that when production was 'out of control' they needed to, at least temporarily, restrict the difficulty of the manufacturing task, they allowed it to grow. Thus instead of achieving improvement they obtained fire fighting. They were presented with a dilemma. The changes they needed in their product ranges to improve their competitiveness were, if they maintained the traditional paradigm, the basis for losing control within manufacturing.

At the micro level the inadequacies of senior managements' control meant that they only knew in detail about a limited area of production performance. Significantly, their control reports did not reflect the issues that they had earlier identified as important to competitiveness. Thus even if their control over the

issues covered by the reports had been effective, their plants would still not have achieved the goals set for them in terms of the KMTs.

The difficulties were not limited to senior management. Production management lacked both suitable frameworks for reviewing its functions and also the information necessary to monitor and regulate performance. Its written information was relatively slow and heavily biased towards output and labour efficiency. Neither did it reflect the KMTs identified by senior management, particularly in terms of quality and delivery. To redress some of these weaknesses production management used a variety of information sources. Meetings overcame some of the delays in obtaining information, but tended to over-emphasise output (workflow) and expediting. This emphasis on output led to month-end storming to meet targeted production levels. This in turn suggested that the targets were met inefficiently and at a higher than necessary cost.

Shop floor patrols, informal contacts and self-collected data widened the sources of information. More particularly, they widened the issues monitored. The patrols enabled production management to test product quality and to gauge the working atmosphere within their plants. They also gave them a form of early warning about future performance. Although they collected some information of their own, inadequate use was made of the large volume of transactional data within plants. Such data was shown to be capable of providing information necessary to the control of production.

It was evident that improving senior and production managements' information would help to bring about better control. Yet, I concluded that better information, covering the full range of KMTs, would not fully resolve the problems. The real difficulties were two fold. The first was production managements' perceptions about their role and the second their understanding about the nature of how to achieve control. They sought stability when they needed change.

They sought control of results when they needed to control the behaviour of the processes involved. Yet, neither of these weaknesses could be adequately overcome by production management on its own. It required similar changes in perception and understanding on the part of senior management. Thus, the primary weakness lies in the paradigm of control. When firms face serious competition the limitations of the paradigm are rapidly exposed. Where the competitive pressure is allowed to generate additional complexity and / or production management is weak, these limitations result in a loss of control.

6. THE 'CONTINUOUS INCREMENTAL IMPROVEMENT AND CONTROL' PARADIGM

6.1 THE 'CONTINUOUS INCREMENTAL IMPROVEMENT AND CONTROL' CONDITION IN PRODUCTION.

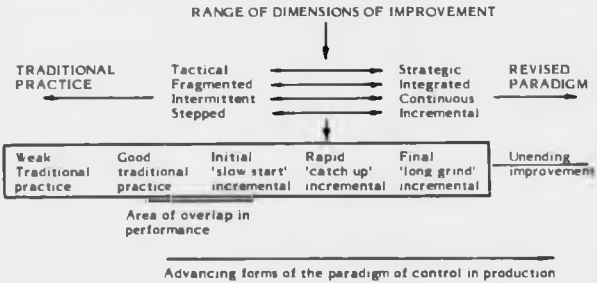
Sections 4 and 5 demonstrated the limitations of the traditional paradigm of controlling production. I showed that when faced with a combination of high complexity and uncertainty stemming from corporate responses to strong competition and internally reactive production management, the manufacturing task became too difficult and in a number of instances resulted in a loss of control. I also demonstrated that even when production managers achieved a state of control they still only sought to maintain the current manufacturing system rather than to make production more controllable. None of the plants had strategies for their manufacturing. Neither did they adopt the Japanese approach of systematically reducing the uncertainty and / or complexity in manufacturing. Based on the above, I considered that the traditional paradigm was inappropriate for firms needing to change in response to competition, especially when competitiveness is based on non-price aspects of production performance. Therefore a revised paradigm of control is required which is more relevant to the conditions likely to prevail within today's manufacturing plants.

The alternative paradigm is summarised in the following proposition. It offers a dynamic approach to the changes in the market place, integrating control and improvement into a coherent framework.

Proposition
The revised paradigm of control replaces the maintenance of stability phase with a dynamic programme of strategically chosen incremental improvements. This becomes the core of the production manager's task, and it depends on increasing the skill and knowledge within production and the adoption of a proactive approach. The aim of the improvements is to support corporate competitiveness.

A diagrammatic representation of the revised paradigm was outlined in Figure 1. Figure 15 below shows a development of the model, concentrating on the interface between good traditional practice and the application of the revised paradigm.

Figure 15 Part of the Framework of the Paradigm of the Control of Production
('continuous incremental improvement & control' condition)



6.11 The Four Factors Affecting the Form of Improvement

Figure 15 shows four dimensions of improvement. The right hand side shows the features found in the 'revised' paradigm, while the left hand side reflects the 'traditional' practices. Although discussed individually, the dimensions need to be considered as a whole, because of their interactive nature. It is evident that these dimensions can only provide a guideline between the 'traditional' and 'revised' paradigms. The critical test is whether a plant is satisfactorily progressing along all these dimensions towards the higher levels found in the 'revised' paradigm.

6.111 Tactical v. strategic improvements

The combination of Wheelwright (1981) and Schonberger (1982) provided the link between the control and improvement processes. Wheelwright linked individual 'improvements' and the corporate strategy, while Schonberger linked improvement and variability. Both showed improvements in a number of Japanese plants stemmed from production managers and workers. This contrasts strongly with the traditional approach in which improvements are staff based and tend to concentrate on technological or procedural changes. As shown in sections 4 and

5, such changes are generally made without a manufacturing strategy, and frequently lead to conflicts and fragmented development. Furthermore, the emphasis on tactical improvements to the organizational sub-systems tends to reinforce the development of sophisticated control systems. These controls in turn tend to reinforce conflicts between staff groups and to emphasise conflicting dimensions of performance.

As noted above, the revised paradigm contrasts sharply with the traditional approach. Production is expected to at least support, and if possible to create, a competitive advantage. This requires a strategic framework to guide the development of the individual sub-systems within manufacturing.

6.112 Fragmented v. integrated improvements

I showed above that the emphasis on the control of resources led to fragmentation of efforts between various staff groups and between line and staff. In the 'revised' paradigm emphasis is on the link between strategy and improvements and the proactive role of production management. The strategic emphasis ensures that investments in improvement are not wasted by unnecessary fragmentation or in piecemeal developments which detract from the critical OWC.

Not only does the traditional paradigm lead to a fragmented improvement process, it also leads to fragmentation of the control systems. Although the production management team has a common role as the recipient of the reports produced by staff, it has little power to modify them or to integrate the diverse approaches of the powerful staff functions. The allocation of tasks between the various staff reflects and amplifies the differences in their roles. Quality is looked at by quality control, delivery and plant utilisation by production control, labour efficiency by work study, while physical plant and processes are the concern of production engineering.

The revised paradigm seeks to overcome the conflicting aims of these staff functions and to provide a means of unifying the efforts to control and improve towards common and strategically important goals. The common denominator in this process is the line production manager.

6.113 Stepped v. incremental improvements

The literature and practice of the traditional paradigm include both incremental and stepped improvements. However, the over-riding emphasis tends to rest on stepped improvements. Such an approach cannot with justice be termed Taylorian, as his contributions were typified by both stepped and incremental improvements. Indeed it can be argued that the techniques of work study, which form an important component of modern improvements, were initiated by Taylor. Nevertheless, Western practice in the post second world war period has strongly favoured strengthening the role of staff specialists who have in turn emphasised stepped improvements, such as introduction of new plant and equipment and / or new systems and procedures, rather than improving the use of existing systems etc. Although uncharted, there appears, at the same time, to have been a move away from work study, which was the chief staff agent for introducing small incremental changes on the shop floor.

6.114 Intermittent v. continuous improvements

Not only are we concerned with the size of the improvements, but also with their continuity of direction. Thus, the revised paradigm seeks a continuous flow of improvements which re-inforce the strategic objectives of the plant. This contrasts with the traditional paradigm, in which the improvement process frequently oscillates between periods of intense activity and periods of relative inactivity.

6.115 An evaluation of the cases studies using the four factors of improvement

I developed the sets of scales shown in Figure 16 below, for the four elements of the revised paradigm. I applied these to the case studies with the results shown below.

Figure 16 Classification of Characteristics of Plants

		CHARACTERISTICS OF PERFORMANCE			
CASES	STATE OF CONTROL	TACTICAL/ STRATEGIC COHERENCE	FRAGMENTED/ INTEGRATED	INTERMITTENT/ CONTINUOUS IMPROVEMENTS	STEPPED/ INCREMENTAL IMPROVEMENTS
Brakes	OOC	2	2	1	1
Kitchen Furniture	OOC	1	2	1	1
Clutches	OOC/IC	2	2	1	2
Pumps	IC	3	3	2	3
Ceramics	IC	3	3	3	3
Medical	IC	4	3	2	3
Food	C&I	4	3	3	4

Key: OOC = Out of Control; IC = In Control; C&I = Control & Improvement; 1 = Inadequate; 2 = Poor; 3 = Fair; 4 = Good; 5 = Very Good

Using the evaluations shown above, it can be seen that none of the cases adequately adopted the revised paradigm. One case, food processing showed indications that it was on the borderline between the revised paradigm and an example of a well organised plant following a more traditional approach. I now consider the criteria underpinning the three phases shown in Figure 15 and establish the differences between them.

6.12 The Three Phases within the New Paradigm

A critical difference between the traditional and revised paradigms is that the latter represents a direction, while the former identifies a final state. In the revised paradigm there is no natural upper limit to improvement, nor is there a maximum level of competence or a minimum level of complexity. Where capability has been low and complexity high, the scope for, if not ease of, change will be greatest. Thus, after overcoming the initial inertia, rapid change is possible, when ideas used in other firms are adopted. Once this transfer of ideas has been absorbed, management will be either forced to rely on their own initiatives or to limit their progress to publicly available knowledge created by others.

6.121 The initial 'slow start' phase

Although the traditional paradigm of control concentrates on maintaining stability, there has always been some concern with improvement. As noted above this was often based on work study, although it also appears in other staff disciplines. The revised paradigm of control radically challenges the practices of both line and staff management, by expecting line managers (and workforces) to take the initiative in accomplishing small scale improvements within production. Initially this is unlikely to lead to a significant difference in the level of improvement in performance achieved between traditional and revised paradigm controlled plants. In this period production management and workforce need to learn the techniques and skills necessary to achieve improvement and to acquire an appropriate sense of direction and confidence. The types of weaknesses, shown earlier in section 5 and part of section 4, would inhibit even this early phase of the revised paradigm.

The move towards a proactive role for production management is unlikely to be accepted equally in all functions within a plant. Differential levels of accept-

ance / resistance are likely to occur. As Schonberger (1986) has shown, the full application of improvement has to be implemented over all aspects for it to be fully effective. Thus, in the early stages of the adoption of the new paradigm, improvements are likely to be slow and thus, in terms of results, not noticeably different from those in the traditional paradigm.

6.122 The rapid 'catching up' phase

Schonberger claims to have identified a number of companies which have become 'World Class Competitors'. He asserts that they exhibited sustained periods of rapid improvement. His arguments tend to emphasise 'catching up' on the application of concepts which are already known to 'world class' firms. He states that Western firms do not need the same time to catch up that it took the Japanese to develop their approaches. He shows that given the right 'climate', the principal techniques underpinning the Japanese achievements in manufacturing can be incorporated into American firms within two to three years. Ed. Hay, a leading American consultant in JIT, supports the view that improvements can be rapid. Given the similarity of British and American approaches to controlling plants, a similar rapid catch up should be possible in the U.K.

6.123 The final 'long grind' phase

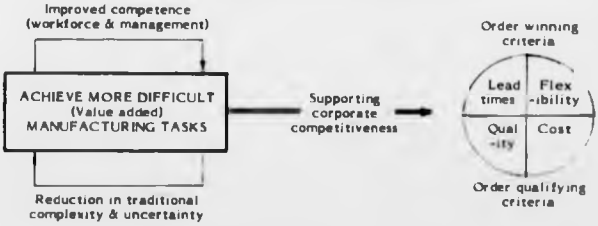
The capability to 'catch up' on the techniques and systems developed by other organisations is clearly important, but has an inevitable upper limit; equality. After that, further progress slows, matching the rate of new knowledge generated either from outside, or within the organisation. It is likely that such knowledge would in practice stem from a combination of these two streams. Although there has not been any evidence offered to date, it would appear reasonable to assume an intermediate phase between catching up with world practice and taking the initiative in developing new ideas and philosophies in firms moving into the

forefront of practice.

6.13 How the Revised Approach to Control helps Competitiveness

The revised paradigm operates in two ways. The first is by simultaneously reducing the difficulty of the current manufacturing task and improving the exercise of control, so that the capability to control exceeds the needs of the current tasks. The second way is by using the 'new' excess capability to perform tasks which give the firm a strategic advantage. The new paradigm is represented in Figure 17 below. It should be noted that the incremental improvements add to and do not replace the stepped improvements in the traditional paradigm. The latter still occur as technological advances are made and / or new systems are required to up date or align the manufacturing capability with the market's requirements. However, as argued by Bohn, these steps can now be undertaken on a much higher level of knowledge developed within production from its new experimental approach. In this way the greater knowledge developed within production can be harnessed, so that firms can incorporate it into the design of its next level of technology / systems.

Figure 17 A Schematic View of the Revised Paradigm



Thus the result of the revised paradigm is increased ability to support the

corporate competitive task. It does so by better performance on some traditional tasks, such as improving cost and quality performance and by accomplishing other more difficult tasks, such as cutting lead times and increasing flexibility. The scale of improvement sought is generally much larger than is sought in the traditional paradigm without the risk of losing control. I include cutting lead times, which is a well know production goal, in the 'more difficult' category, because of the size of reduction, which can be as large as 95% of previous levels. To accomplish this approach managers must exercise their control and seek improvements in ways which are consistent with the four dimensions shown in Figure 15 above; that is they must be strategic, integrated, continuous and incremental. Above all the state of control must be maintained even when the market forces changes in direction. Control is achieved by providing information which monitors the strategically important issues and stimulates the problem solving necessary to achieve the next set of improvements.

6.2 SECONDARY EVIDENCE OF THE REVISED PARADIGM

Proposition
To achieve optimal performance firms require manufacturing strategies which directly address the complexity of the manufacturing task. Leading firms eliminate unnecessary complexity and uncertainty, substituting for them alternative, commercially beneficial complexities and dramatically increasing competence within manufacturing.

The dominance of the traditional paradigm in the cases in sections four and five, as shown in Figure 16, made it desirable to find secondary evidence of the application of the revised paradigm. Were I to rely entirely on the direct case evidence, doubt might be thrown on the viability of the revised paradigm. However, using secondary evidence to support it, the challenge is instead to the practices of control in the case studies. A qualification is necessary, since, because the evidence is secondary, the data captured does not always fully reflect the variables that I wish to cover. This limited the conclusions that I can safely draw from such work. The major limitation was that most of these studies show the results achieved but show only limited evidence of the means used to

accomplish them.

6.21 The Strategic Approach of 'World Class Competitors'

Proposition
The design of the product range and selection of processes significantly influences the complexity of the manufacturing task. Such decisions provide a vital link between control and strategy, which is generally inadequately recognized in Western manufacturing organizations.

I showed in sections 4 & 5 that the control of production performance did not adequately support the senior managers' strategic goals identified in the cases. Additionally, I only found one instance of an attempt to start formulating a manufacturing strategy. The evidence about the Japanese use of manufacturing strategy is mixed. Although Wheelwright considers Japanese manufacturing operations to be strategically oriented, there is little evidence of any use of formalized manufacturing strategy methodologies, such as proposed by Hayes & Wheelwright or Hill. Nevertheless, it is equally clear from the innovations they have made in manufacturing that they have a strong strategic perspective. They have not simply accomplished conventional production goals at a higher level, but have sought to achieve mixtures of goals which were previously considered impractical. Abeggien & Stalk (1985) show with reference to Toyota forklift trucks, how some Japanese manufacturers, after many years of 'focusing' production, have widened their product ranges while still remaining price competitive. Similarly Kiyoshi Suzaki (1986) has shown that the growth of product variety is widespread in Japanese companies ranging from the colour of automobiles, to varieties of white and brown goods and canned beer. Previously, such strategies would have led to substantial cost increases. They are now achieved without losing cost advantages or worsening delivery performance. In other words, companies have remained in a state of control, while improving their competitiveness.

The link between complexity and focused production provides a clue to the sources of improvements in the production processes and manufacturing system.

Conventionally a wide product range marginally reduces the demand for individual product lines, but increases total demand. The effect on production is either constant changeovers between products or the build up of stocks while each product line is produced in sequence. Both approaches incur considerable additional costs. Abegglen & Stalk have estimated that cutting a product range to one quarter of its previous level could reduce employment by almost 75% and total costs by 30%. Many of these savings occur in the offices. To control a wide range of products, sophisticated control systems are used to monitor the progress of the individual batches. Other systems record the level of quality etc. Figures produced by Abegglen & Stalk suggest that a doubling of a product range could lead to a fourfold increase in overheads per unit produced. As Miller & Vollman (1983) have shown, the 'hidden factory' needed to run complex plants is a major cause of high overhead costs. Yet, despite the historical advantages of focused production, the Japanese are now rapidly widening their product ranges and still achieving an approximately 30% price advantage over Western competitors.

Abegglen & Stalk show that it is in industries with more complex (multi-stepped processes) production systems, and thus where control is most necessary, that the Japanese enjoy their highest comparative levels of productivity. In engine and transmission plants they are twice as productive, while in stamping plants they are only 20% better than leading American plants.

This is not the first time the Japanese have achieved such strategic breakthroughs. Previously, they successfully shifted the 'quality / cost' trade-off curve, so that, at least in terms of compliance, higher quality results in lower costs. Indeed, quality specialists, such as Crosby (1979), now argue that the cost of compliance to quality standards is zero.

The link between complexity (& uncertainty) and strategic improvement is

critical. I showed above that a number of leading Japanese plants have achieved distinct competitive advantages over their Western counterparts where complexity is normally at its highest. Given this link between strategy and control, it can be seen that part of the control / improvement process must involve learning how to control complexity and how to integrate it with a commitment to improvement.

6.22 A Commitment to Continual Improvement

Proposition
A commitment to a strategically chosen, systematically and continuously applied process of incremental improvement is essential to the attainment and maintenance of a state of control in a dynamic environment.

Schonberger (1986) coined the expression 'World Class Competitor' to describe companies with outstanding levels of manufacturing performance. He found a common characteristic of these companies was a dedication to improvement, which he likened to that of Olympic athletes, contending that they were committed to:

> "...continual improvement in quality, cost, lead time, and customer service" and that they believed that such improvements were: "possible, realistic and necessary".

Such improvements in performance have come from both increased competence within production and from learning to control the conversion process, at a much higher level than was previously considered realistic. The control and improvement of the conversion process comes from making it less variable and its systems and / or technology less complex. However, the size of improvements sought and their strategic nature makes it essential that there is a formal system to support the improvement efforts. Such a system has to provide direction, training and support as well as create a new climate within the organisation.

6.221 Corporate methodologies of improvement

Sumitomo Electrical Industries have used a formal system for promoting small scale improvements in manufacturing since at least 1978. A number of these groups' papers have subsequently been published in English. The Sumitomo system is based on small voluntary teams, similar in form to Quality Circles. They meet regularly to produce improved methods of manufacturing or of organising production. The study papers produced by these groups cover a wide range of topics and are of considerable rigour, one such paper being awarded the Nikkei prize for Quality Control by the Deming Prize committee.

Improvement programmes are also adopted by some companies in the U.K. The Ford programme tends to concentrate on improvements in quality, but is not exclusively limited to such efforts. Harrison (1987) has shown that Mullard has an improvement programme which integrates strategic goals and small improvement teams into a coherent attack on enhancing their manufacturing systems.

6.222 Improving competence to exercise control, through training

The traditional paradigm relies on intermittent staff led changes to the production process, to restore declining competitiveness. This requires little training of the workforce and limited training of supervision. The 1987 NEDO report discusses comparative expenditures on training, showing that British firms spend one sixth of their American, one tenth of their West German and one twentieth of their Japanese counterparts on training. The Kaishas, (Japanese Corporations), generally place a very heavy emphasis on training. This is consistent with their goal of growth and policy of life-time employment for key workers. Growth leads not simply to new tasks, but to the elimination of old tasks. When this is combined with life-time employment, it is necessary to retrain the workforce. In addition, the policy of life-time employment means

that the firms can reap the benefits of their training expenditure.

Daly et.al. (1985) afford a number of important insights into the significance of technical competence and its link with training. They contend that German production management exhibits greater technical competence, in its lower echelons, than does its British counterparts. Hayes & Wheelwright (1984), noted some differences between North American and German production management. They referred to this as low level technical competence, the low level being in the hierarchy not the competence. Daly et.al. highlight the different roles of foremen in the U.K. and Germany. They claim that the British foreman is predominantly appointed for his management / human skills, while German foremen are primarily technically skilled personnel, who receive some managerial training. In both Daly's and Hayes & Wheelwright's accounts, there is an emphasis on good practices that reduce the risk of undesirable behaviour occurring within the processes of production. Machine maintenance, worker training, machine running speeds etc. all affect the extent to which the system is, or is not, in control. Other issues, such as greater emphasis on mechanical handling, clearly received more attention in the German plants. These have an immediate impact on the control of the number of production indirects in the plant. Many of the items outlined above are essentially process skills, rather than control system skills. Control in this context stems from doing the right things well, not from correcting what should not have occurred. The emphasis on developing the skills of low level members of the organization helps to bring about this different type of control. In a number of British companies the priorities appear to be reversed. The shop floor skills are seen as less important and the staff skills as more important. Nevertheless, as I have shown earlier, even the 'more' valued managerial skills receive scant attention. It can be argued that this only creates a self fulfilling requirement. It can be seen from the above that British manufacturing industry places a relatively low priority on improving the competence of its production workforce and management. Without such competence firms will not

be able to take on the more difficult manufacturing tasks which enable them to create the comparative advantage that leads to their out performing rivals in the market place.

6.23 A Strategic Approach to Reducing Complexity / Uncertainty in Production

Proposition
Internal and external uncertainties and complexities must be systematically eliminated to produce a state of control which can be sustained without undue expenditure on a formal control system.

I discussed how 'world class manufacturing' companies set significantly higher goals than traditionally run plants. To meet them, particularly those of greater flexibility and reduced lead times, products need to flow rapidly and reliably through the production system. A common cause of delay and unreliability in production systems is generally complexity and uncertainty. In the traditional paradigm of control the delays and variability caused by complexity and uncertainty are largely accepted as inevitable. As shown in the literature, the primary means of limiting the complexity is to protect the technical core from the vagaries of the environment. The revised paradigm, however, is based on reducing this internal complexity and uncertainty by eliminating variation within production and only buffering it from the outside world when the internal variations have been minimised.

While is is difficult to develop good measures of complexity, it is easier to measure its effects. Complexity and uncertainty take many forms and their removal is dependent on detailed knowledge of the actual, rather than intended, working of the system. If considered only in cost terms, some uncertainties are uneconomic to remove. However, their removal may enable the accomplishment of other more complex tasks which were previously impractical. Where such an approach would make the firm more competitive, their elimination is justified.

6.231 Complexity / uncertainty and quality

Erratic quality is a common cause of uncertainty in production. However, the combination of high speed production processes and batch manufacturing generally hides this uncertainty in a buffer of stock. Thus the problem appears to be with inventory rather than uncertainty. This leads to one of two additional costs; a better than usual process makes too many items and a worse than expected process requires 'make-up' batches and causes delivery delays.

The Japanese emphasis on quality is wider than considering the goods received by the customer. High quality is also sought for its effects on the production system in terms of higher utilization of resources, better levels of process yields etc., Abernathy et.al. (1981). They conducted a number of extensive discussions with U.S. industrial executives, who identified and ranked a number of factors they considered to be most important in determining relative U.S. / Japanese performance. The highest factor at 40% was seen as process yields. The difference was largely attributed to quality levels and maintenance of equipment.

6.232 Uncertainty and the production process

Proposition
The manufacturing process can be designed to give greater reliability. A critical part of achieving improved reliability depends on using production workers and managers to identify weaknesses and to involve them in solutions.

Production processes, particularly in batch work, exhibit considerable variation and thus lead to uncertainty. This uncertainty occurs in the time at which items will be available and the yield levels of the products produced. A critical feature of the JIT system has been the substitution of standardized procedures for more complex and uncertain procedures. Machine setups represent one of the most concrete examples of this subsection. Shingo (1985) claims that 50% of changeover times are caused by the need for adjustment in tools. This 50% is an average which differs considerably between setups and gives their completion a

low predictability.

High speed, high volume manufacturing systems can be vulnerable to breakdown. Schonberger (1986) advocates using multiple, slower production lines which can continue working when the more complex 'advanced flow lines' break down. Haydon (1980), a Ford executive, reports Toyota being able to achieve 'first run capability of paintshops' as follows:

Table 22 A Comparison of the First Run Capability of Paintshops

Toyota	95%	Valencia	75%
Toyo Kogyo	85%	Halewood	68%
Sarlouis	75%	Dagenham	50%

He also reported the comparative levels of 'down time' between Ford and Toyo Kogyo. The former was 49%, while the latter was 20%. Similar operational impact was also reported by the above author in terms of the high level of 'availability' achieved in 'Green Grinding operations'. The author did not identify whether any proportion of the reduced 'down time' was due to the reduction in scrap rates, although it would appear from the broader evidence on Japanese practices, that this was a likely factor.

Shingo (1985), outlining the 'improvement of process', highlights the multi-functional attack of the Japanese and identifies both the value analysis and industrial engineering as central vehicles in improving manufacturing processes. It should be noted that his reference to industrial engineering is closer in practice to British production engineering than work study. Although reference is made to Galbraith and use is made of the American Society of Mechanical Engineering symbols, the technological nature of the conversion process changes discussed are closer to production engineering than to work study.

6.233 Uncertainty reduction (external elements)

Much of the uncertainty faced within production is generated outside production management's direct control. Variability exists in the pattern of customer orders and supplier deliveries and quality. All three elements of uncertainty have been tackled in recent years to reduce the uncertainty on production.

Freezing production schedules has long been advocated as a means of providing production with a stable period of certainty and thus the ability to plan its work effectively. Although many firms have set this as their formal policy, as in the clutch case, it is often impractical to maintain. The length of the lead time in many plants makes this an unrealistic objective. However, with the dramatic shortening of lead times in 'world class manufacturers', it is now possible to ensure that schedules can be protected for 2 to 4 weeks ahead.

Supplier delivery and quality problems provide further causes of uncertainty within production. The use of supplier vendor rating systems, evaluating both delivery reliability and quality, are now used in many firms. The Open University (1986) has shown Rank Zerox using such systems to control supplier performance, with the effect of giving greater stability within production, and thus making it more controllable.

6.24 Changing the Measures of Performance

Proposition
The measurement of performance in the revised paradigm reflects the wide set of ways in which production supports corporate competitiveness and also reflects the strategic value of monitoring the levers of the future state of control.

The increasing role of manufacturing in corporate competitiveness was highlighted above. It requires revisions to the measures of performance used at senior and production management levels and to the information systems supporting performance measurement. Kiyoshi Suzaki (1986) suggests that the flexible

organizational structures needed to support the new form of competition have less clear performance measures than exist in firms following the traditional organization structures. However, it may be that the data is gathered directly by production managers / workers and is no longer perceived as measures. It is also more likely that the intangible aspects of performance will receive more attention than under the former approach.

Successful changing of the measures of performance, however, depends on the goals of the firm. If they only perceive of production goals in terms of cost reductions, their measures are likely to be limited. There is, however, evidence of a widening awareness of the other goals which can be achieved via manufacturing. New & Myers (1986), in a survey of 239 U.K. manufacturing plants, found that their priorities were as follows:

Table 23 Competitive Priorities over the Next Two Years
(in a sample of 239 U.K. manufacturing plants)

Competitive Aim	% of Plants Ranking factor 'high'
Consistent quality	73%
Dependable delivery	58%
Low costs	46%
High performance products	43%
After sales service	38%
Fast deliveries	26%
Rapid product design changes	15%

In similar surveys, Ferdows & de Meyer (1984) found comparable priorities in their study of European companies.

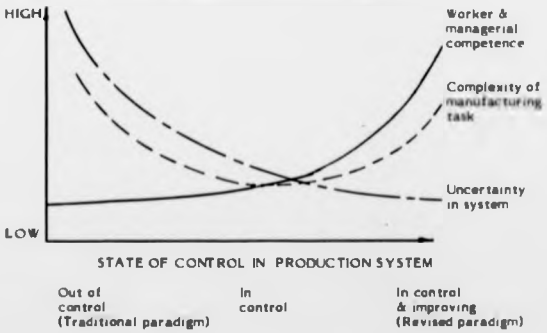
The priorities in Table 23 overlap and diverge from those in Figure 17, in a number of important ways. Quality and cost are consistent in both lists. Shorter lead times are partly reflected in the desire for 'fast deliveries' and ' rapid product design changes', although New & Myers did not report any seeking of greater flexibility within production. Yet it is these aspects of performance,

flexibility and radically reduced lead times, that has given many of the world class competitors their distinctive edge.

Given the pattern of goals shown in Table 23 above, it is reasonable to argue that the system of performance measurement should enable senior managers to monitor progress, and production managers to gauge their progress, on the intermediate measures as well identify any obstruction which might eventually affect meeting the goals.

The state of control is not achieved by simply monitoring the end dimensions of performance; it is equally important to monitor the intermediate levers of the future state of control. Thus, the measurement of performance has to be improved so that it monitors both current achievements, such as quality, cost, lead times and flexibility and intermediate dimensions such as uncertainty reduction and improvement in competence. The relationship between these three factors and the state of control is shown in an illustrative form in Figure 18 below.

Figure 18 An Illustration of the Relationship between Uncertainty, Complexity and Competence with the State of Control



It will be noted that the expected movements in competence, uncertainty and complexity are not linear. The difference in 'competence' between being 'in' and 'out of control' may not be very great in absolute terms. The reduction in uncertainty and complexity may be more significant. As can be seen above, uncertainty continues to decline to very low levels in the revised paradigm, while competence has undergone a major improvement. Complexity, however, reveals a more convoluted path. After an initial reduction, it plateaus until the benefits of reduced uncertainty and higher competence are felt. Once they come into effect, complexity can rise as firms learn how to stay in control while undertaking more commercially beneficial tasks.

Senior management need to translate the conceptual relationship in Figure 18 above into concrete measures of performance which reveal the state of the 'levers of control'. Illustrative sets of these intermediate measures of the 'levers of control' are developed in Appendix B.

Although the traditional emphasis on inappropriate internal and narrowly selected end measures of performance has come under increasing criticism, Skinner (1978), Schonberger (1986), few other authors have adequately discussed the need to replace the old internal measures with new ones which show how the firm is progressing on the levers of the future state of control.

6.241 Senior managements' monitoring of strategic variables in production performance

I showed earlier that the information received by senior management was loosely linked with the way in which these firms competed. Given production's wider role in modern competitiveness, this defect has to be overcome. Even within the narrower view of manufacturing competitiveness in New & Myers, it is evident that delivery and quality performance are vital issues. Gauged in terms of stated priorities they often exceed the importance of cost performance. However, as was shown above, and confirmed, (in part on delivery), by New &

Myers' study, the level of concern is not matched by appropriate performance measures.

As well as wishing to monitor these performance goals, it will be desirable for senior management to be able to monitor, at appropriate intervals, how well production are performing on a series of intermediate aims, which eventually enable them to achieve their competitive goals. Hayes & Clark (1986) recognize that senior managements' control systems are ill-suited to this task. They consider that traditional accounting data, which is a major source of reports, is ill-suited for comparing manufacturing performance between plants and is even less effective in 'the important contributions that (production) managers can make by reducing confusion in the system and promoting organizational learning'.

As well as monitoring current performance, senior management needs to monitor those dimensions of current practice that act as levers on the future levels of performance. These levers of future performance concern issues requiring manufacturing policies to guide subordinates so that their control and improvement activities meet the plant's strategic goals. Yet, it is in the area of formulating future performance that senior managements' reporting systems are weakest in the traditional paradigm.

In addition to the under monitoring of strategic performance, senior management are frequently over burdened with less significant details. Both New & Myers and Hayes & Clark criticise the emphasis on direct labour. Each point out that other costs, which are generally several times larger, receive less detailed attention, (e.g. purchased items which were 52% of ex-works cost in New & Myers' study and staff costs, which at 20-25% were 4 to 5 times that of direct labour in Hayes & Clark). Although the need for good monitoring of the strategic variables is becoming more widely recognized, there is, as yet, no evidence that firms have developed appropriate means of monitoring them.

6.242 Senior managements' monitoring of routine production performance

Senior management must monitor routine as well as strategic performance. However, many of the reports traditionally available are ill-suited to the revised role production is now required to play in competitiveness. One such weakness involves the need to achieve and maintain a high level of certainty and a low level of complexity in production. While the measurement of complexity is often recognized as a strategic variable, (un)certainty is more closely related to routine activities.

One innovative form of measurement, showing the level of internal certainty in the transfer of work between departments, is the CLIP score developed in Mullard, Harrison (1987). The system scores 1 for all items in a period which are within -5% to + 10% of scheduled output. Items higher or lower than this score 0. Performance is gauged by the percentage of 1s out of the scheduled range in each department / section. The system generally starts with monthly schedules and the frequency is progressively reduced until they are daily. Departments with high daily CLIP scores provide reliable deliveries to their receiving departments or customers.

6.243 Production managers' monitoring of production performance

The changing nature of the production managers' role in competitiveness has a direct effect on the areas of performance they need to monitor. In particular, the need to achieve improvement, often via uncertainty reduction / complexity removal, requires them to monitor different dimensions of performance to those traditionally identified in POM literature.

The research also noted differences in the time intervals of the reporting

systems between the case studies and accounts of the Japanese plants. The intervals in the case studies were longer, with the emphasis on weekly / monthly output and quality and monthly costs and delivery. In the Japanese reports output and quality were monitored hourly and daily.

The more frequent reporting, particularly of output and quality, was critically linked with exposing problems. Management in the Japanese plants appeared to recognize that the traditional production system leads to considerable variation in performance, often stemming from the uncertainty within its technology and / or procedures, Hall (1983), Schonberger (1986). In well run traditional plants these variations average each other out over the medium term (weekly / monthly) with the result that performance targets are met. In less well run plants some of the losses are not recovered and performance slippage occurs. Thus, in my terms, the plant is 'out of control'. The more frantic the efforts to overcome these slippages, the easier it is for the plant to degenerate into 'fire-fighting'. However, although the well run traditional plant has hidden its losses in the averaging process, these variations are signs of areas for potential improvement.

The Japanese manager and engineer is, however, urged to adopt a sense of immediacy as well as forward thinking. This is sometimes called 'SENTI Control'. The word SENTI means to seize the initiative over a rival. They use this idea in the form of 'feedforward', with the emphasis on creating worker skills and technical reliability which enable them to 'guarantee that objectives are met'. Sumitomo report that their work leaders find this approach far more efficient than learning through making mistakes.

They are also encouraged to see the above moves to 'SENTI Control' in terms of a progression from weekly control, through day-to-day, hour to hour and even beyond instantaneous control to the 'final' state of feedforward control.

6.25 The Role of Information in the Control and Improvement of Manufacturing Performance

The goals of the 'world class competitors' have been shown to be higher and different from those of the traditional manufacturing company. This has an impact on the information required at all levels. Sumitomo Metal Industries describes one of these differences, with the aid of the following diagram.

Figure 19 A Comparison of the Traditional and Revised Control Cycles

The traditional approach often leads to large volumes of information, at a high cost, which produce low value information. Such information has limited effectiveness in helping managers improve their competence by learning from the past or in helping them identify where reductions in complexity / uncertainty would increase performance.

We have seen that the traditional paradigm leads to information systems which:

(a) failed to report on a number of strategically important dimensions of manufacturing performance

(b) were slower than the information needs of the users

(c) were heavily oriented to transactions and with little emphasis on analysis

I showed that the way in which manufacturing could compete in the revised model required consideration of different dimensions of performance, and thus, information.

6.231 Information needs at the operational level

The revised paradigm requires more information and a more rapid provision of that information. However, it does not automatically require that that information is formally processed through a corporate MIS. The rapid movement of work through modern manufacturing systems is frequently too fast to be accommodated by the conventional staff based MIS. In addition if the new data was gathered and processed by staff, as distinct from production managers / workers, it would lose much of its impact, as well as become expensive to produce.

Some of the additional information necessary to enable high co-ordination between operations is achieved by KANBAN cards, while other information is provided by the 'ANDONS' lights (score boards), Hall (1983), Schonberger (1982 & 1986). Neither system incurs staff time to compile records of transactions or summarise data for routine reports. Furthermore, the information is both more rapidly available and, because it is produced on the shopfloor, is more easily understood by other shopfloor workers.

The scoreboards are located so that they are visible to the maximum number of workers in the production area. Some boards use coloured lights to indicate the activity status of the work centres. Under this system it is normal to record the hourly output compared with the scheduled. This enables tight control of the short term over this important dimension of performance, while still ensuring both that a high level of co-ordination is attained and that problems are clearly highlighted for improvement.

The yellow warning lights are used in some plants to fine tune the balance between work stations. Traditionally this has been done by industrial engineers, but now with the information available to the shop floor workers, they can take effective control over this component of the system. The solution is likely to be

better than that from the industrial engineers, who have to rely on concepts of the average (qualified) worker, rather than the set of individuals who actually make up a real workforce.

The role of record keeping becomes critical in respect of the problems identified. These must be recorded, so that their relative occurrence is known and so that senior management is able to check that problems are not allowed to reoccur.

6.252 Data collection and analysis by shopfloor workers

Whereas the traditional paradigm of control is based on line management action (and often staff data collection / analysis), the revised paradigm is predicated on workers taking a more proactive role in data collection and analysis. The use of production workers in this way not only speeds the receipt of the information but also makes it more likely that they will react positively to shortfalls in performance.

Schonberger (1986) illustrates this with an example from H.P.Greeley, where delays occur in a small JIT based assembly unit. There workers record all delays on a white board and analyse them via a 20 minute daily meeting. The workers not only analyse, but also undertake other tasks previously only performed by managers or staff; line re-balancing as a consequence of their analyses.

6.253 Using coloured lights as controlling mechanisms

Although not written information, the system of red and yellow lights on the assembly line has been a well documented form of providing data, Schonberger (1982 & 1986). The red light, informing of a worker controlled line stop, is considered valuable because it is anticipated that it will stimulate learning. Thus learning arises from a combination of line stops, bringing managers and engineers

down to the problem on the shopfloor and from the view that problems must be resolved, not just temporarily overcome. Compared with the predominant reaction in the traditional paradigm of shunting the problem off to a repair area or finding some temporary palliative, the Japanese approach leads to more problems being drawn to management's attention and being resolved.

6.3 EVIDENCE FROM DIRECT SOURCES

Evidence of the adoption of the revised paradigm was sparse. Only one case could, in any realistic sense, be considered to follow the revised paradigm, and that only in part. This does not mean that the other cases did not seek and achieve improvements. Rather, it reflects that in these other cases they had not set their target levels of improvement to give them a distinctive competitive edge. Production performance was to be raised to respond to competition rather than to create a competitive advantage of their own. The commitment to continuous incremental improvement, characteristic of the best Japanese plants, did not exist.

Even in the food processing case, where the improvement process had recently become an integral part of the system of control, the vision of where improvements could and should be sought was more limited than appears in the Japanese firms. In addition it should be pointed out that the flow process nature of the technology used in this case tended to exaggerate the extent to which it was adopting the higher paradigm.

An exception to the lack of improvements sought in the other cases was shown in the ceramics case. Although the plant lacked a strategic approach and its control reports were less than satisfactory, it did seek a limited range of improvements in an interesting way. Because of the scarcity of evidence in this area, I include observations from the case, although it did not meet the criteria to be

classified as a follower of the revised paradigm.

Proposition
The revised paradigm links the control and improvement of production performance with the corporate strategy, via the difficulty of the manufacturing task. It seeks, in both the stepped and incremental phases, to systematically reduce uncertainty / complexity and improve capability to accomplish strategic tasks. In the short term this leads to reducing the difficulty of the manufacturing task, while long term efforts are also made to increase the capability to perform difficult tasks.

6.31 Competitive Pressures in the Ceramics and Food Processing Cases

The plants in both case studies faced strong competition. The ceramics competition was primarily overseas. Its high value products competed against a few specialised North American and European competitors, while its lower value products competed against third world suppliers. The Managing Director did not consider either market large enough to support the technical and design effort needed to compete. This technical component of competitiveness was most necessary in the high value market sector. Competition in the food case was also strong, but this time from both U.K. and European producers. Overall demand for canned food products has declined, as consumers have sought to move away from the can into alternative packaging, coupled with seeking the removal of emulsifiers and sugar. To counter this trend, the plant modified a number of its traditional products and additionally it also diversified into a number of higher value 'non-canned' food products. These high value products faced strong competition from established large companies in continental Europe.

Both managements sought improvement to corporate competitiveness with changes in the production capability. The degree and direction of these improvements varied between the plants. In the ceramics case the improvement was sought primarily by introducing a new range of high value products. In the food processing case there was a commitment to continuously improve the conversion processes. However, as will be shown below, the main thrust of improvement was labour saving via capital expenditure. Other important dimensions of perform-

ance were not pursued with the same alacrity.

6.32 The Absence of a Formal Manufacturing Strategy

Figure 16 above showed the evaluation of all the cases in the 'strategic-tactical' scale. The medical case was the only one in which there was any formal attempt to even start formulating a manufacturing strategy. As I showed above this case was not classified as part of the highest category because of the absence of improvements by production management and also because it did not seek to create a distinctive competitive advantage in its manufacturing activities.

Neither the food processing nor ceramics cases had written manufacturing strategies. However, as shown above, there is no clear evidence that successful Japanese companies have such strategies in the form advocated by Western specialists. The critical issue was not the possession of a written strategic plan, valuable as that may be, but the degree to which the approach adopted within production was strategic and coherent. Such an approach would be reflected in the manufacturing task. It was anticipated that in the early stages of a strategy this would show up as simplification of the task, making it capable of execution, while in the later stages of strategy development it would lead to increasing the capability to perform complex tasks which add to corporate competitiveness.

6.321 The clarity of the manufacturing task

In the absence of a formal manufacturing strategy, I considered that the degree of strategic thinking would be most clearly displayed in terms of the clarity and unity of the perception of senior managers about the manufacturing task. Secondly, I expected that such perceptions would be reflected in their control reports being consistent with their stated aims and containing data which would show the direction of performance as well its current achievements.

Examining the clarity and unity of approach within the functions in the food processing case, I found them highly consistent. They universally emphasised improving quality and lowering labour costs as their aims. While I would question the depth of such perceptions, I was left in no doubt that all senior managers in the case agreed on these aims. In the ceramics case the same level of unity was not evident. There was, however, little open conflict in aims, as in the clutch or brake cases. The most common theme was cost control, with differences in reducing development and / or production lead times, quality etc. Such differences were not wide or intense, but they indicated the scope for developing a greater commonality of approach on strategic issues.

The analysis of the manufacturing aims in the food processing case showed that despite senior management's commitment to improvement, they lacked suitable information with which to evaluate their plant's manufacturing performance. The measures of manufacturing performance were very similar to those in companies whose aims were more static. The case revealed a very positive approach to its labour performance. Its information in this dimension was analysed, rather than simply reviewed. It was projected over the succeeding 12 months to predict the level of achievement expected. This data was used in guiding the company in making difficult pricing decisions.

6.322 Changes in the complexity of the manufacturing task

The ceramics case had developed a dedicated manufacturing unit, which produced the final stages of a set of high value repetitively demanded products. This had the effect of reducing the complexity of the manufacturing task. The earlier stages of production were accomplished in the main plant.

The complexity of the manufacturing task in the food processing case moved in two directions, depending upon the sub-unit of production concerned. In the

cannary, the developments in process technology and product strategy led to a small reduction in the product range and a consistent set of criteria being applied to those products which were produced. In the non-cannary unit, the product range was increased by 83%.

Management in the ceramics case made no deliberate efforts to expand the ability of its production functions to successfully accomplish more difficult manufacturing tasks. However, in the food processing case, there was a programme of worker training which contributed to their competence to perform a wide range of tasks. The food processing case faced a major expansion of product recipes and receptacles in one of the major divisions of the plant. In this instance, the expansion in the product range was reactive, rather than stemming from a deliberate attempt to create the competence to accomplish more difficult manufacturing tasks. I was able to establish in discussions with corporate and production management that in neither were there any plans to improve competitiveness through enhancing production's ability to do more difficult tasks than could be accomplished by rival producers.

6.33 Fragmentation or Integration of Control and Improvements

Figure 15 shows a fragmentation-integration scale which reflects the degree of unity in efforts to exercise control and / or improvements. Clearly, the possession of a manufacturing strategy would enhance such unity, although the absence of such a strategy does not prohibit its existence.

The food processing case exhibited a high degree of integration between its various specialist functions and its production management. To an incalculable extent this was helped by the relatively low number of specialist staff, and the limited number of specialist functions in the plant. The organization structure supported this integration with the Work Study Engineer reporting directly to the

Production Director. The Head of Maintenance Engineering and the Production Director worked closely with each other, ensuring effective implementation of small changes in the plant and equipment. These changes went beyond repair and were closely linked with improvements, such as energy saving and wastage reduction, through reducing the level of damage to cans in transit through a better mechanical handling process.

6.4 SENIOR MANAGEMENTS' CONTROL OF PRODUCTION PERFORMANCE

Section 4 showed that senior managers' information in the 'in control' cases inadequately reflected their KMTs. In examining the food processing case, as the best of the available sites, I checked whether this link was more effective. Given that the case was only in the initial stages of the revised paradigm, I did not expect to find any major difference in approach.

Secondly I compared both the order winning criteria and the 'levers of control' dimensions of manufacturing performance in the case with the model of the revised paradigm discussed above; additionally, some references are made to the ceramics case.

6.41 Comparing the Reports in the Food Processing Case and 'In Control' Cases

A simple comparison of the percentage of reports by topic received by the Managing Directors in the 'in control' cases and the Managing Director in the food processing case is shown below as Table 24.

Table 24 Comparing the Percentages by Topic in the 'In Control' Cases and Food Processing Case

Category of Performance	Average for 'In Control' Cases	Food Processing	Food Processing (adjusted)
Physical quantities	32	12	21
Plant utilization	10	-	-
Plant load / schedule	9	49	9
Labour performance	6	5	9
Stocks & WIP	17	5	9
Quality	3	-	-
Financial	4	15	26
Sales & delivery	19	15	26
Total	100%	100%	100%

Table 24 gives a misleading impression in two senses. Firstly, it over-emphasises the plant load / schedule category in the food processing case. Secondly, by over-stating plant load / scheduling, it under-emphasises the other categories.

This misrepresentation occurs because the Managing Director received a daily report on the schedule of output and planned changeovers in the plant. These 20 reports represented a large proportion of his 41 reports per month. However, their relative frequency did not reflect their impact. He stated that he only received them to keep in touch with what was going on in production, rather than to use them as any form of control. I therefore recalculated the proportions after allowing 9% for the reports in this group, so that they matched the average in the 'in control' cases. The results are shown in the 'adjusted' column.

Given the factors discussed above, there was little difference in the pattern of reports, except for the wider variety of individual documents on costs in the food processing case compared with those in the 'in control' cases.

6.42 The Coherence between the Managing Director's Control Reports and his Order Winning Criteria.

I interviewed the Managing Director in the food processing case, identifying his OWC and competitive strategy. We discussed his use of routine control reports and I also asked him whether he required any other information to exer-

cise control of production. Table 25 below summarises the reports received by the Managing Director, which are compared with his self-identified OWC. It also outlines a number of deficiencies in this information.

Table 25 A Comparison of Order Winning and Qualifying Criteria and the Managing Director's Control Information.

Order winning criteria	Control reports received	Deficiencies in reporting
Price / cost	Labour performance, materials, energy use & full monthly accounts	No measurement of complex interaction between storage, energy & material costs
Quality dispatched	None	No monitoring of the non-health related aspects of quality
Service	None	Relied on complaints for delivery failure. No measure of response time (particularly in developing new recipes)

Notes:

1. The list of order winning criteria shown above reveals all the criteria for the six representative products.

2. The criteria differed between product groups; price, quality and service were, however, common items.

3. Service is related to the tendency of the company's few large customers to require ex-stock supply based on call-off schedules. They also expect the plant to give rapid service to unexpected changes in schedule.

4. Rapid introductions occur in non-canned products, which require reduced lead times to develop new specifications and containers.

As can be seen from the summary above, the Managing Director's control information reflected the same pattern of weaknesses as those of his counterparts in the 'in control' case studies. Thus, even though I regarded the firm as the best of the seven case studies, the Managing Director was still attempting to control his plant without direct information about quality and delivery performance. While he clearly lacked any of the more sophisticated measures referred to above,

these 'advanced' measures could not be expected to play an active role when basic dimensions of 'order winning criteria' were not monitored.

6.421 Strengths and weaknesses in the system of reporting order winning criteria

As shown above, the main OWC were price, quality and service. The Managing Director received reports on issues affecting the control of production costs; labour, material usage, purchasing, energy. Both costs and variances were reported monthly. He anticipated an improvement in the analysis of variances when a revised computerized accounting system came on line.

Cost analysis was particularly difficult because of the interaction of material usage rates, energy and storage costs. Products fell into two categories, seasonal and non-seasonal products. English seasonal fruit and vegetables command a premium over continental produce. These products have relatively short seasons and decisions have to cover requirements for the anticipated year's demand. Even within a season, the cost of materials and the energy consumed in production vary considerably. The classical semi-seasonal produce is carrots. Later in the season, purchased material may be lower, but the amount of surface needing removal is greater. This lowers yield and increases energy consumption. However, the later the production, the lower the total storage cost. A problem of similar complexity occurs in respect of scheduling production of non-seasonal produce. The availability of a particular fruit or vegetable and its price could lead to either early or late production of another product. The most complex aspect of this problem was in terms of the knock-on effects on the cost balance in other products. Neither the current nor proposed accounting systems were expected to examine this class of problem. Decisions were therefore made judgementally. In both of these areas the development of 'decision support' models may have facilitated more effective decision making by the Managing Director.

The control of finished stocks was particularly important, given the wholesaling role carried out in this case. No analysis was made of the optimal combination of holding finished goods and production run lengths. The minimum run in the main plant was half a day, but was normally not less than one whole day. With high speed processing lines this could amount to several months sales. Currently the cost of the hygiene programme, which occurred with every product change and / or end of day, was considered too high to permit less than half day length runs. In principle this problem is the same as the changeovers in manufacturing plants and, as I have shown, dramatic improvements have occurred in that area.

I concluded that in respect of the costs needed to support price competitiveness the Managing Director was as well provided for as any of his counter-parts in the study. However, in common with them, he too lacked strategic measures which could help him make fundamental shifts in cost performance.

Table 25 showed that although product quality was an important OWC, it was not covered by reports to the Managing Director. To some extent this is explicable, as food products have to pass rigid Governmental testing procedures prior to dispatch. However, considered strategically, this explanation is inadequate. Firstly, the tests were about compliance to health standards and did not consider presentational and other aspects of quality. Given that he was seeking to 'win', rather than 'qualify' for orders in terms of quality, the criteria must be more than compliance to health standards. These other dimensions of quality lie in the presentation of the can and its contents, as well as the flavour of the produce. I should, however, note that the Production Director checked presentational quality daily. Another dimension of quality is the nature of the additives, sugar, emulsifiers etc. This has become an important dimension in all foods in recent years. Given these points, I consider that he should have sought reports at regular, if longer intervals, such as three monthly, on these more subtle but critical aspects

of quality.

The final dimension of the OWC was service. I found that in common with the rest of my survey, records were not kept of the plant's delivery reliability. The second dimension of service, that of meeting customer revisions to schedule, was similarly unrecorded. However, in this area, I would have expected a strategic analysis of performance in order to evaluate, at say three monthly intervals, the capability to respond to such requests. The Managing Director was, however, aware of these schedule changes and production's / wholesaling's ability to meet these requisitions. What he was unable to analyse were the trends in this performance, as all the data was verbal.

It emerged that production in the smaller jams etc. unit was frequently asked to prepare new recipes which might later be converted into orders. This development process was critical to qualifying for future orders from some of the larger customers. I found that this aspect of performance was not monitored. I also found that some recipes took seven months to develop, against ten days from leading competitors.

I concluded that the Managing Director needed to review the service performance in the three dimensions discussed above and to ensure that a programme of improvement was developed to eliminate uncompetitive parts of the system. Overall the review revealed that the Managing Director's reports did not adequately reflect how well the plant met its OWC, nor did it provide a sufficient basis for the strategic review of performance. Taken overall, the Managing Director's control reports were indistinguishable from those of his counter-parts in the 'in control' cases.

6.422 Strengths and weaknesses for monitoring the 'levers of control'

The review of performance against the OWC is a limited, if vital, part of the control information needs of plants which aspire to achieve 'world class' competitive performance. A second set of issues involves the levers on future control. These, as discussed above, involve uncertainty, complexity and competence within the manufacturing techno and infrastructures. While such reports are uncommon in traditionally controlled plants, they occupy an essential strategic role in competitiveness, in those following the revised paradigm.

The food processing plant's use of flow process technology contributed to the reduction of complexity and uncertainty compared with batch process technologies. This is because flow technologies tend to expose any impediments to the rapid movement of material or bottlenecks in the process. Nevertheless some complexity and uncertainty remained, in particular, variability (thus uncertainty) in the time to pressure heat the cans for sterilization. The time varied as a result of the pressure level (steam generated) and the condition of the pressure vessel. This time was carefully measured, but mainly used as part of the quality control procedure. Although supervisors did monitor it and quickly call for maintenance when it exceeded a set limit, no evaluation was made of the average level of variability experienced, nor was there any direct link with the improvement programme to reduce the variations taking place.

Complexity existed via the product range in the smaller of the two production units. It had expanded the range in response to competitive pressure in the market, rather than as a means of deliberately creating an advantage via better manufacturing. The expansion occurred without supporting changes to the technology or managerial systems. This led to a process mis-match as discussed by Hill. Control became more difficult to accomplish because of the mis-match and the increasing complexity in product range. Neither the mis-match nor

complexity were shown up in the control reports produced.

The production management was aware of the importance of worker competence (skills) in achieving good performance. The Production Manager in the larger of the two units organized two courses a year in conjunction with the Industrial Society and pursued an active programme of job rotation, so that all workers could perform well on at least two tasks and most on many more. Although this practice was followed, discussions with the Manager revealed that he saw no reason to monitor the level of competence via any written control system, as he considered his personal recall of events eliminated the need for such formal monitoring.

Thus, the three areas involved in the levers of control in the food processing case were unmonitored. Were the case to move to the 'rapid improvement' phase, which is based on the ability to accomplish more difficult tasks, it is likely that senior management would need to monitor these less obvious dimensions of production performance.

6.5 PRODUCTION MANAGEMENTS' CONTROL AND IMPROVEMENT OF PERFORMANCE

I showed above that the control reports available to the Managing Director in the food processing case differed little from those in the 'in control' cases. I divide the examination of the Production Managers' control processes and improvements into two parts. The first part, that of 'control' is considered in 6.51, while the second, that of 'improvement', is discussed in 6.52.

6.51 The Preferred Sources of Information

Table 26 below shows the production management team's preferred sources of information in the food processing case. These were compared with the averaged preferences of the 'in control' case studies.

Table 26 Production Managements' Preferred Sources of Information

PREFERRED SOURCES OF INFORMATION	FOOD PROCESSING	AVERAGE ('in control')
PRODUCTION MGT'S OWN SOURCES		
Personal contacts	2*	1
Production meetings	2*	2
Touring the plant	1	4
STAFF BASED SOURCES		
Written reports	2*	3
Non-production meetings	5	5

* joint score

Table 26 shows a number of important features. Firstly, the joint scores for personal contacts, production meetings and written reports suggest a lack of differentiation in the priorities of information among the production management team. Secondly, in so far as any pattern did emerge, it was not markedly different from the average of the 'in control' cases, except in respect of touring the plant. As can be seen in the Table, touring the plant received the highest overall score as an important source of control information, whereas, in the 'in control' cases, it was perceived to be fourth out of five categories. This emphasis on touring the plant is consistent with Peters & Waterman's (1982) 'managing by walking about'.

6.511 The type of information gathered in tours of the shopfloor

In the food processing case both Production Managers and Supervisors cited shopfloor patrols as their primary source of information. I therefore investigated what type of information they gathered and how it was used. This was accomplished through interviews and accompanying them on some of their patrols.

The common theme in the interviews was the speed in obtaining information and the level of detail obtained. They also stated that they attempted to 'feel out' worker attitudes during the patrols so that they were quickly aware of any

discontent among their staff.

During the patrols which the Managers and I made on the shop floor, I identified that they continually checked the quality of work and the environment, using both visual and tactile senses. The Managers generally ran their hands round the rims of cans, testing the smoothness of the seals. They would constantly look for items such as the build up of gum on labelling machines and the level of housekeeping to check for excess wastage of material spilt on to the floor, and similarly at the way items were stacked etc.

I considered that the common characteristic shown by both the interviews and the patrols was a search for deviations from their view of normality. The Managers appeared to have developed in their minds a concept of smooth running sections. Their patrols gave them the opportunity to look at items that they had discovered from experience could disturb that normality. Thus their approach to control was in a sense preventive rather than simply corrective and in this way consistent with the revised paradigm.

6.512 Production meetings

Despite being rated as the joint second most important source of information, there were no regular meetings specifically devoted to routinely controlling production. However, part of the wastage meeting, considered in section 6.52 below on improvements, discussed aspects of the flow of work between sections. Given the primary focus of these meetings was improvement, I defer discussion of them until later.

6.513 Production management's written reports

The Production Managers in the food processing case received a different

pattern of written reports than their counter-parts in the other case studies. This made direct comparison of their contents, using the classification used in sections 4 and 5, unrealistic. The primary difference was a much greater emphasis at production manager level on examining the way the conversion process was performing. This took the form of detailed daily reports showing the fill weights, quality checks, process behaviour in terms of temperature etc. These reports were not exclusively daily but, where appropriate, recorded performance at intervals as short as 30 minutes.

The process orientated data recorded temperatures in and out of the processes, line speed, valve settings, fill weights, cooking durations, dial readings etc. Other reports gave detailed recordings of the quality of product and presentation, including quality of can and label. These reports were used, according to the Production Managers, to ensure that the processes were being correctly followed. This is clearly critical in food products and is in part mandatory. In particular, canning regulations require companies to maintain records for three years after processing.

Based on the detailed information received the Production Manager in the cannary calculated his process yields. (His counter-part in the preserves department had this information provided, although no-one could explain why this difference occurred.) Based on these yield values, the Production Manager maintained a detailed daily log of process efficiency, which he used as a means of controlling the wastage of materials. As I noted in the review of the Managing Director's reports, the management regrettably was not currently provided with a means of scientifically evaluating material yield losses and the energy consumed in the conversion process.

The process performance information was also used by the Chargehands on the line as, for instance, when the time taken to perform a pressurization of filled

cans took longer than scheduled, they would use the data to call up maintenance to adjust the steam pressures.

The Production Manager did not himself maintain quality control records about the product, other than about fill weight or presentation. However, he maintained detailed control over this critical aspect of performance by visiting the quality control department approximately hourly. He argued that this aspect of control was too important to rely on written reports which would 'inevitably be slower than visiting the Q.C. department'. In addition to the above, he was also able to see, during his shopfloor visits, the records, maintained at each of the major units in the plant, of half-hourly quality checks on vacuum and fill weight. In this context he claimed that 60-70% of the time he did not need the records, as his shopfloor patrols had already provided him with the data. The above should not distract from the importance of his other written reports. These covered costs, labour productivity performance etc. However, it was evident in the interviews and observing his behaviour that the immediate control of the plant was accomplished through the combination of shopfloor patrols and daily detailed monitoring of the process. The greater emphasis on rapidly gathered data, with its richness of detail, reflected a number of the characteristics discussed above in the Japanese approach to controlling production. As I noted earlier, this was in part due to the nature of the flow process technology employed, rather than as a result of a superior strategic concept of control. Despite the lack of obvious intent, the effect was in part similar to that experienced by the Japanese. However, as I will discuss below, a major difference existed in the link between their use of the data in improvement, compared with that made by the reported practices in Japanese case studies.

6.52 The Improvement Process

The food processing and ceramics cases were both distinguished by small scale

improvements to the manufacturing process. Although management in neither plant perceived these efforts as a means of enhancing control, it had that effect in both cases. The commitment to process improvement was, however, restricted to a narrow range of issues. While in both cases the aim of improvement was found, in that such improvements stemmed from the Manufacturing Directors and the meetings under their respective chairmanships, neither case had developed the type of formal system of improvement found in Sumitomo or Mullards. Both cases approached improvement via raising quality / reducing waste, and to this the food processing case added improvements in productivity. One aspect of quality improvements differed between the cases. Both cases had to achieve high level compliance to standards; in the food processing case all products had to achieve high quality as an order qualifying criteria, while in the ceramics case OQC only applied to the higher value products. Thus, the scope for, and type of, improved quality differed between the companies. In the food processing their improvements were to taste, presentation etc. of the products, as well as waste reduction. In the ceramics case there was scope for better quality to the customer in some products, as well as reducing the costs of quality overall. Both cases set targets for reduction in wastage rates, which can be interpreted both as cost savings and quality improvements.

I tested whether the Cannary Production Manager and his Superintendents maintained the objectives of better quality / reduced waste, identified by senior management. They were interviewed to identify which aspects of performance or working practices they wished to improve. Twenty-one responses were elicited, and only two items, training and output, were mentioned four times. Eight items only received one mention. The list of items covered is shown below as Table 27.

Table 27 Issues Identified as Important for Improvement by the Production Manager and / or Supervisors in the Food Processing Case

Issue mentioned	No. of mentions	Average ranking of mentions
Improve output/ throughput	4	1.25
Worker training	4	2.25
Working conditions	3	2.33
Reduce wastage	2	2
Supply of raw materials	1	2
Methods of operation	1	2
Motivation	1	-
Safety standards	1	3
Co-operation between line & service depts.	1	- 3
Modernization of plant (selective)	1	- 4
Passing on quality information	1	- 4
Communications	1	4

N.B. The 'average ranking' is calculated from totalling the priorities and dividing by the number of times an item was mentioned.

It can be seen from the above Table that not only was there a wide diversity of goals, but there was little connection between those set by the Manufacturing Director and those sought by his staff. I considered this discrepency was a significant factor in the failure of production to move beyond the basic level of the revised paradigm. In order to overcome the diversity of goals and to ensure that those chosen were appropriate, a formal system for achieving improvements, linked with the competitive goals, needed to be developed.

Turning to the two aspects of improvement identified by the Production Director, labour productivity and waste reduction, I examined in detail the process used to achieve them. A central vehicle in both cases was waste reduction / quality improvement meetings.

6.521 Production meetings and the improvement process

I noted above that there were no routine morning 'control' meetings in the food processing case and only limited weekly meetings in the ceramics case.

However, in both cases meetings were regularly held as part of their improvement processes. In the ceramics case the Manufacturing Director held a fortnightly 'scrap' meeting, which aimed to monitor and steadily improve the process yield. The meetings involved most functions, although maintenance engineering had been allowed to drop out of attending them. The group worked through a list prepared by the Manufacturing Director of all batches which in the previous two weeks had a 10% or greater rejection level.

Once on the list, valuable repeat orders would 'officially' continue to receive attention until their yield losses were cut to the 2-3% level. These lower level targets were not precise or followed up with a great deal of attention. However, if they remained above 10% they were usually followed up until the target was met. However, I observed that some jobs were considered too difficult for this target and these were simply passed over. The improvement process was also limited in its commitment, in terms of priorities. On a number of occasions they identified products with high yield losses, which they claimed could have been cut dramatically if they had used a different process. However, the plant required to achieve this better quality had been 'lent' to design and development a year earlier and was not available to production. The combination of imprecise targets, which in any case did not seek zero defects, and the shortfall in commitment to use the best processes showed that, despite the obvious achievements, they were not yet adopting the revised paradigm.

The Manufacturing Director in the food processing case introduced a series of meetings devoted to identifying and monitoring improvements. The initial theme of these meetings was improving yield levels and reducing scrap rates. The meetings brought together production, stores, maintenance engineering and work study in attempts to improve manufacturing performance. The Manufacturing Director encouraged the group to use a simple form of 'brain storming' to identify agenda items for improvement. The identified projects were monitored at the

fortnightly progress meetings.

In both case studies the major theme of the meetings was quality / yield improvement. These 'improvements' were primarily aimed at cost reduction, rather than providing the market with superior products. While such cost savings were clearly important, they did not go as far as the creation of a distinct competitive advantage advocated in the revised paradigm.

The meetings, particularly in the food processing case, reflected a number of the characteristics that might be expected in the revised paradigm. Yet, in a number of significant ways, they lacked the final ingredients that distinguished what occurred from good 'conventional' practice. In particular, the improvements were not part of a strategy for manufacturing, nor were they structured in ways which promoted monitoring of the results and their application in other areas. However, most significantly, they did not have any link with training programmes etc. which could ensure that the necessary skills were acquired and deployed in achieving improvements.

6.522 Improving labour productivity

Labour productivity in the food processing case was monitored effectively, with considerable attention being paid by all levels of management to the reduction in manhours per tonne of output. Until 1986 the plant in this case had easy access to capital from its then parent company. The parent group had been willing to invest in process improvement which reduced labour, as long as there was clear evidence of productivity improvements and of profitability. This interest helped stimulate the development of the labour reporting system and encourage widespread interest in its results. Figure 20 below reproduces a section of one of these reports.

Figure 20 Reporting Labour Performance in the Food Processing Case

Month	Man Hours per Tonne Produced Monthly 1984/5 (a)	1985/6 (b)	1986/7 (c)	a to b	b to c
April	9.17	9.53	8.56	+ 4.5%	-11.8%
May	9.90	10.16	8.96	+ 3.0%	-13.5%
June	9.95	9.41	8.76	- 6.2%	- 8.5%
July	9.86	8.60	8.45	-14.7%	- 8.0%
August	10.70	8.54	8.88	-23.0%	- 2.0%
September	11.28	8.52	8.06	-27.6%	+ 4.7%
October	9.77	8.48	78.11	-15.0%	- 6.4%
November	10.23	8.44		-20.0%	- 5.2%
December	10.09	8.29		-20.6%	
January	9.96	8.21		-20.0%	
February	9.39	8.35		-13.0%	
March	9.03	8.36		- 9.1%	

As well as the above report, the data was entered into a Z chart on the Production Director's office wall. This quickly showed up any loss of momentum in productivity improvement. As noted above, most of the improvements in productivity stemmed from investments in new process technology.

In 1986 the plant was sold and its new parent company indicated that the easy access to investment would no longer exist. Management were advised that they would normally have to accomplish improvements within their existing resources. This in turn stimulated the Production Director to seek improvements via reductions in the level of wastage in the plant and wholesale stocks. Although most of these improvements were expected to come from wastage reduction, he still anticipated productivity improvements via work study from better line balancing. An example of this was work study and engineering working closely together to improve pressurization times, so that an additional pressure load per shift could be achieved with the same manning levels.

6.523 Reducing the level of wastage

The ceramic process is characterised by process yield losses. These occur through variability in the shrinkage rate and through inconsistent distortion of the 'green' ceramic when fired in the kiln. The amount of distortion was often significantly influenced by the block (called a stagger) on which the ceramic was

placed during firing and on the conditions of the furnace. When yields were good, over production occurred but when the yield levels were worse than expected, both losses and delays were high. The delays frequently led to late delivery and extra expenditure as small 'corrective' batches were urged through the plant, causing knock-on delays to other products in the system.

Two improvements illustrate the type of work being undertaken. Firstly, there was a reduction in wastage. This was initially identified in the fortnightly scrap meeting, where they found that damage occurred to components when they were 'green', prior to firing. This was overcome by designing trays which held a set number of components each in its own foam lined section. Several materials were tried and eventually the Supervisors found the ideal material which virtually eliminated damage from the movement of material. The second improvement involved staff and supervision working together to identify why the reject rate from a particular kiln was high. It was found that the worn elements in the kiln were oxidizing and this affected the glazed finish of the product. This was overcome by replacing the kiln.

In the food processing case improvements were also triggered from regular meetings under its Production Director. The Work Study Engineer undertook a careful analysis of wastage levels by production lines and was able to show major differences in two areas. Firstly, the wastage losses from bent / distorted cans were significantly different between product lines. The differences were traced to the handling devices used and these were changed. A second difference occurred between cans which were labelled later when a particular customer was found for them. The losses on labelling later (or relabelling when necessary) were much higher. This analysis led to reconsideration of the policy of relabelling and to attempts to improve the secondary labelling process. Other small scale improvements were replacing the heating of sauces in vats, with heating them at the point of delivery by passing them through a heat exchanger in the

piping as the sauce arrived at the cooking stage. A number of similar improvements to energy consumption and material yield levels were achieved by the close working together of production management, work study and the Plant / Maintenance Engineer.

6.524 The limits to improvement in the cases

The improvements discussed above were clearly of benefit. However, it was also evident that they were more limited in concept and in means of achievement than would be expected in a plant fully following the revised paradigm.

The detailed knowledge of the production processes gained by the Production Managers in the food processing case in particular might have been expected to produce an even higher rate of improvement than they accomplished. In considering why they did not achieve a more rapid rate of improvement and learning, I identified that they were not trained in, or aware of, the wide range of tools and techniques with which to structure the examination of their daily phenomena. Without this structuring, the richness of their data was in practice an obstruction to identifying common patterns.

In considering how improvements / learning took place, two different approaches can be identified. At one extreme is the highly quantitative school, which is performed by specialists using mathematics, statistics and increasingly simulation methods. At the other extreme lies the simple techniques of work study and the methods used in quality circles. While I did not expect to find production management using much of the former, I did expect to find them using some of the latter approaches. The food processing case employed a very effective Work Study Engineer who spent considerable time on examining the process for inefficiencies and in producing informative reports on labour performance. His analyses were, however, limited to descriptive rather than analytical

statistics. I was unable to find any use or even knowledge of the simple 'problem exposing' techniques used in quality circles, either in the staff groups or production management, in either case study. Taken in combination with the absence of a formal programme of improvement, the weaknesses in analysis tended to ensure that the firms did not advance to the full scale adoption of the revised paradigm of control.

6.6 CONCLUSIONS ABOUT THE REVISED PARADIGM OF CONTROL

The foregoing analysis has shown that only one of the seven cases adopted any noticeable elements of the revised paradigm of control. However, looking at the wider evidence I showed that the paradigm is being adopted, at an empirical level, in companies seeking to achieve world class competitive standards in the performance of their production departments.

I showed that the failure to adopt the revised paradigm was fundamental. Not only did senior management in these cases fail to monitor the dimensions of performance that directly reflected their own stated OWC, they did not recognize the importance of monitoring the strategically important issues, such as complexity, uncertainty and competence, which would indicate the likely state of control in the future.

At production management level the individuals did not perceive it to be a critical part of their function to reduce uncertainty and / or enhance the competence to perform their roles. The cases lacked means of ensuring that systematic improvements were accomplished.

Athough I have demonstrated a series of illustrative control reports, shown as Appendix B, which could be used to guide senior and production management where improvements can be made, such controls are only tools. The critical

dimensions that these tools require are the formation of a coherent strategy for the manufacturing function conjoined with the determination to bring about continuous incremental improvement within production.

7. CONCLUSIONS

7.1 THE RELEVANCE OF THE TRADITIONAL PARADIGM OF CONTROL TO COMPETITIVE MANUFACTURING

The research showed that the traditional paradigm, developed in the classical POM literature and followed in the surveyed case studies, remains the dominant, if flawed, practice of control. I concluded that conceptually and practically the traditional paradigm leads to the separation of control and improvement. As a consequence production management fails to develop the incremental improvements advocated in the revised paradigm. Traditionally controlled firms are therefore limited in their scope for increased competitiveness based on excellence in manufacturing. In its more severe forms, the traditional paradigm acts as a brake upon the development of competitiveness, because production managers seek to maintain stability in between the major revisions to the manufacturing technology and procedures, when they should be leading the introduction of incremental change. To meet the market's pressure for higher performance, both theory and practice promote introducing step changes in products, technology and procedures. Such changes are implemented by various specialist staff groups. When these changes are either introduced late or made inappropriately, they exacerbate the difficulty in maintaining control of production.

A further weakness of the traditional paradigm is that even when production managers seek to maintain stability, their attention is focused on a narrow sub-set of performance criteria, such as output levels and cost. Other vital criteria, such as delivery and quality, receive less attention. In its more acute forms, this leads to a loss of control and quite often to fire-fighting. In less serious instances, stability is maintained until the next staff based 'improvement' is brought into play to restore competitiveness.

Conclusion
The traditional concept of control is inconsistent with creating a distinct advantage based on production performing more difficult manufacturing tasks than competitors, while staying in control.

7.11 Differing Basis for Controlling Uncertainty and Complexity

Both the traditional and revised paradigms considered uncertainty and complexity. The traditional paradigm of control used two inter-connecting bases for controlling these characteristics; bureaucracy and MIS. The revised paradigm also used two approaches; manufacturing strategy and simplicity.

The traditional paradigm is exemplified by Thompson's argument about the protection of the 'technical core' from the vagaries of the market. This protection incurs hidden costs; buffers (usually of inventory), expensive systems of MIS with corresponding 'high' overheads in staff salaries and a failure to adequately exploit improvements in production. The magnitude of these hidden costs has been shown by Abegglen & Stalk.

The revised paradigm reduces uncertainty and complexity with a combination of manufacturing strategy and systematically developed simplicity as in the Japanese manufacturing techniques. Information, as distinct from MIS, plays a vital role. Whereas the MIS approach is staff led and tends to treat adverse variances between average results and standards as 'mistakes', the revised information approach looks at the variation within the overall data and treats it as a source of learning. An important change also occurs in the nature of the information captured. The new form of control information seeks to identify trends in uncertainty, complexity (and competence) so that production management can identify where it can make further improvements in systematic reduction of undesirable variations and complexity.

7.12 The Promotion of Learning and Improvement.

Managers and workforce in the traditional paradigm lacked adequate problem solving skills. More significantly they did not see problem solving as part of their

role. They ran the system; it was for staff to design a better one.

I showed that unless a large cadre of staff was employed, the detailed information needed for such improvements was only available in the production departments. The revised paradigm showed that combining this information with manager / worker problem solving, which was consistent with the plant's goals, into a formal improvement programme can lead to the integration of control and improvement processes in ways which enhance competitiveness.

The implications of reliance on the traditional paradigm in the case studies was recognized to be serious. If, as appears likely, similar findings occur in the wider population of British manufacturing companies, it would help to explain why many sections of UK industry are less competitive than necessary.

Long run manufacturing competitiveness is dependent on maintaining a state of control, while producing satisfactory performances which competitors cannot adequately match. Seeking to attain and then maintain such a position involves a major dilemma. The stronger the competition, the nearer the firm will be pushed towards the knife edge between high performance and loss of control. The fundamental flaw of the traditional paradigm of control is that it is at this 'moment of truth' that the approach is weakest.

7.2 OVERCOMING WEAKNESSES IN SENIOR MANAGEMENTS' CONTROL OF PRODUCTION

I showed that the traditional paradigm resulted in senior managers adopting a limited view of the potential of production as a means of increased competitiveness. This was reflected in four ways:

(a) the absence of strategies for manufacturing
(b) restricting the monitoring of performance to a narrow set of issues
(c) the lack of improvement programmes involving production managers and / or workers as active agents for change
(d) not providing production workers / managers with the tools of analysis or problem solving skills needed to control and improve performance.

The revised paradigm outlined in section 6, and supported with Appendix B, demonstrates a dynamic alternative to the reactive approaches shown in sections 4 and 5 above. It offers a means of using the control process as a way of increasing the competitiveness of firms, as opposed to the exercise of control as a restrictive mechanism to attain compliance.

Conclusion
The research shows that when senior managers' practice of control is based on the traditional paradigm, their firms are deprived of a major source of improvement and thus fail to achieve the potential competitiveness available to them.

7.21 The Need of Strategic Direction from Senior Management

Since the case for manufacturing strategy has been well made elsewhere and does not need repeating here, I therefore limit my observations to the following. Miller & Graham's call for an integration between operations (production) control and a firm's competitive strategy has been shown to be necessary. The revised paradigm has shown the basic steps in making this link. It has shown that a manufacturing strategy is essential. It has also shown that building up the managerial / worker competence and removing all avoidable complexity and uncertainty can lead to manufacturing being able to perform tasks which were previously impractical. Where such efforts are strategically directed, they can be built into a competitive advantage. Without such a strategic perspective, the complexity of the manufacturing task is likely to grow in ways which add difficulty without financial benefit.

Conclusion
The absence of strategies for manufacturing leads to production being assigned tasks which are unneccessarily complex, which impairs their control of performance. It reinforces a reactive rather than proactive approach by production management.

7.22 Restricted Monitoring of Performance

The lack of strategy and the low level of analysis of the available data by the staff groups were demonstrated in the aspects of performance that were and were not monitored. The weaknesses of commission were the over-emphasis of total output levels and cost control. The weaknesses of omission were two fold; the under-emphasis of the OWC / KMTs of delivery and quality and the absence of intermediate measures reflecting uncertainty, complexity and competence.

It is evident that having established their strategies, senior managers must ensure that their implementation is systematically monitored. The gaps between the senior managers OWC / KMTs and their control reports demonstrated in the cases must be eliminated or production will mistakenly conclude that in terms of delivery and quality it must avoid being caught out, rather than achieve excellence. The non measurement of the intermediate dimensions will signal to production that its role is compliance rather than improvement. In the absence of unambiguous messages to the contrary, production will react to the issues covered in the control reports, which usually emphasise the short term and effectively direct attention away from the longer term.

Despite the considerable overhead created by the large number of staff required to operate the staff based MIS approach, the evidence showed that the information provided was of little value in resolving problems. The information arrived too late, was biased towards output and costs and hid rather than demonstrated the cause of the lost performance. The revised paradigm overcomes these weaknesses.

Conclusion
Senior managements' control of production needs a strategic perspective of the potential for increasing corporate competitiveness. This perspective must be linked with the system of monitoring, particularly of delivery and quality. The monitoring must include dimensions such as uncertainty, complexity and competence.

7.23 Involving Production Managers and Workers in Improvement

The manufacturing strategies developed must be based on a proactive role for production managers and workers. The revised paradigm showed that the development of the ability to perform 'profitable', (as distinct from unnecessary), difficult tasks, depended on production reducing uncertainty and avoidable complexity and increasing competence. Improvements in these areas can be helped, but not achieved, by staff. Senior management must ensure that there is a formal programme for improvements and that the organisational structure encourages rather than inhibits such improvements.

Conclusion
Production will not replace its traditional reactive role and seek long term incremental improvements in the manufacturing system and procedures, unless there is a formal programme, supported by appropriate organisational structures.

7.24 Provision of Production Management / Workers with Tools of Analysis by Senior Management

The reactive role occupied by production management in the traditional paradigm has meant that neither managers nor workforce are adequately trained in analysis or problem solving. The skills needed to eliminate problems are different from those of fire-fighting, yet it is in the latter rather than in the former that most production managers excel. The strenuous efforts of Production Managers in the brake case to control, via fire fighting, was an example of great efforts mis-directed by a combination of the absence of strategy, inappropriate controls and the inability to eliminate recurring problems. All the cases reflected weaknesses in problem solving skills, even though this fact was largely hidden, in that most of the managers concerned did not expect to be involved in improvements, which they saw as staff roles. As I showed above, such improvements were mainly limited to stepped changes in technology or procedures. The changes in production technology in the brake and food processing cases, changes in product range and design, in the clutch, pumps, medical and kitchen furniture cases, changes in systems, (PPC and SPC), in the clutch, pumps and ceramics

cases, were all staff led. Senior management did not look to their production departments to proactively increase their competence to perform difficult tasks, and therefore they did not train them in problem solving skills considered to be unnecessary.

Conclusion
Incremental improvements need to be made by those working daily in the systems. Production managers and workers must be trained in the skills of problem solving, so that problems can be eliminated and fire-fighting avoided.

7.3 OVERCOMING WEAKNESSES IN PRODUCTION MANAGEMENTS' CONTROL

The weaknesses of senior managements' approach to production set out a framework which makes it difficult for individual production managers to adopt radically different approaches. While it is impractical to expect production managers to make the necessary changes on their own, it is unlikely that simply changing the approach of senior management will on its own achieve the desired results.

I showed that many of the production managers in the cases accepted their role was primarily achieving output targets within budget. They also accepted that much of the technical element of their job was determined by functional specialists.

Two weaknesses were revealed:

(a) imbalance between the control reports and the Managing Directors' OWC.

(b) little emphasis on improvement in performance and better control by systematic learning.

7.31 Imbalanced Emphasis on Issues Covered by Control Reports

The emphasis by senior management on total output and costs was strongly reflected in the reports received and the practice of control by production

managers. The lack of reports on delivery and quality resulted in comparatively less attention being given to these issues, which were limited to controlling the level of 'backorders' and controlling the cost of rejected / reworked production.

I established that production managers operating according to the traditional paradigm did not seek 'intermediate measures' reflecting the conditions within production and which thus would indicate the likely future state of control. The emphasis was on meeting total output and cost targets, rather than reducing uncertainty and complexity or improving competence.

I showed that producing the necessary reports was neither expensive nor time consuming. I also showed that with only a small additional effort the information could be presented in ways which promoted attention to learning and improvement. In addition I produced a number of illustrative reports which showed how the intermediate dimensions of performance could be monitored.

I concluded that until the production managers' control systems reflected the dimensions of performance identified as order qualifying and order winning criteria, they would continue to produce distorted approaches to the control of production performance. Further, that until production managers monitored the intermediate dimensions of performance, the manufacturing task would remain unnecessarily difficult to accomplish. This difficulty would in turn inhibit the scope for production to perform new tasks and thus increase the competitiveness of their firms.

Conclusion
The control reports received by production managers must be revised, so that they reflect a balanced perspective of the way production is expected to contribute to competitiveness.

7.32 Increasing Learning and Improvement within Production

The traditional production manager's role of maintaining stability in product-

ion was shown to be at variance with the revised role of leadership in introducing improvements to the manufacturing system and procedures. I showed that the production managers had only limited awareness of which issues should receive priority in making the plants more competitive. They lacked measures of performance to guide them on whether the end results or the intermediate variables were performing satisfactorily. Finally, they were shown to lack training in the tools and techniques which were needed to bring about improvement.

The revised paradigm showed that such strategies, controls and techniques are available. It also showed that applied consistently, the cumulative effect is a major shift in the performance of the plant in terms of its ability to perform difficult manufacturing tasks and to stay in a state of control.

Conclusions
I concluded that production managers need formal training in the concepts of the revised paradigm and techniques of problem solving in order to enhance their firm's competitiveness.

7.4 THE IMPLICATIONS FOR TEACHING PRODUCTION MANAGEMENT

The thesis has important implications for teaching POM to potential senior managers and production specialists. It re-inforces the case put forward by Skinner, Hayes & Wheelwright and Hill that production has a major contribution to make to the creation of competitive advantage and must therefore be included as a vital component of corporate strategy. It has shown a link between control and strategy via the difficulty of the manufacturing task, which is not clearly reflected in previous work. This theme needs to be incorporated into the other elements of strategy teaching. It has been shown that senior managers do not clearly link the way they control with the way they wish to compete. It is therefore necessary to increase their understanding of the consequence of the narrow measurement of performance and to demonstrate the effect of the failure to develop the potential of production as a major source of small scale, but cumulatively large, improvements. The generally low status assigned to production management has

been too readily reflected in omitting it from the training of potential senior managers. This must be overcome and a more commerically aware, proactive approach adopted.

The implications for teaching production managers are many. The traditional paradigm, separating control and improvement, must be eliminated. Production managers must be trained both psychologically and technically to adopt proactive approaches to their role. They must learn to seek the introduction of improvements to the manufacturing system and procedures, which reinforce their company's competitive position.

For those of us who teach POM, the implications are important. We must strengthen the theoretical underpinnings of the subject to create a more unified perspective of POM and translate the emergent theory into concrete proposals, which will help senior corporate and production management to compete more effectively.

7.5 THE IMPLICATIONS FOR FURTHER RESEARCH

The open ended nature of the design of this research inevitably means that it leaves many questions unanswered and raises yet other questions. These questions can be grouped into the following areas.

7.51 Further Development of the Revised Measures of Performance

Although the research involved ten sites (seven in detail), not one of them adequately followed the revised paradigm. The sites were characterised by their normality rather than their excellence. Further research is needed, in advanced UK firms, to develop the measures of performance outlined in this thesis. Such measures would provide measures of complexity, uncertainty and competence

which could be used in making comparisons between firms.

7.52 Development of Improvement Programmes

The research showed that there is little known about the design of systematic incremental improvement programmes. It is evident that the Japanese use such programmes, although little is known about how they are developed, by whom etc. It is equally clear that without such programmes the level of improvement and its direction will be inadequate. I therefore suggest that a further topic for research is the link between manufacturing strategy and improvement programmes.

7.53 Developing Production Management / Worker Skills

The effective implementation of the revised paradigm is dependent on production management and workers being able to solve problems. While an outline of these skills is suggested in the material on Quality Circles and Small Improvement Groups, this would appear to only afford a limited part of the solution. A challenge is the way in which the production managers of tomorrow are prepared for this change in role. Further research is needed into both the content and means of teaching these managers. Such research should not constrain itself within the assumption that the Universities are the best vehicle; they have in many instances signally failed in the past to teach POM in its competitive and strategic context, and they may continue to fall short in the future.

APPENDIX A - DETAILED METHOD OF STUDY

A.1 INTRODUCTION

The research was conducted in two phases reflecting developments in my understanding over time. These developments led to changes in some of the data collected and in its analysis. In particular they enabled me to simplify the identification of the critical issues to control by substituting OQC and OWC for KMTs. This change in turn made it possible to eliminate the collection of some of the detailed data on manufacturing policy. In part two an increased emphasis was placed on examining the factors influencing the complexity and uncertainty of the manufacturing task as well as on production managements' and workforces' competence to perform their tasks effectively.

The part one methodology was used in the study of the clutch, brake and pump cases. The part two methodology relates to the ceramics, food processing, kitchen furniture and medical case studies.

A.2 THE PART ONE RESEARCH METHODOLOGY

The part one method of study adopted a wide perspective in an attempt to identify the primary factors influencing the control of production. The clutch case acted as a pilot study and I progressively revised the method of study in the brake and pump cases. Thus by part two of the study I was able to use a simpler, uniform approach to the investigation.

A.21 How the Firms Competed

The way in which each of the firms studied competed was identified with the aid of five strands of analysis, which need to be evaluated as a whole. These were:

(a) the strengths and weaknesses of key competitors
(b) interviews with the Managing Directors on a series of manufacturing policy issues
(c) examination of the Managing Directors' expectation of the contri

bution to competitiveness from their various functions
(d) an examination of the ranking of the KMTs
(e) preparation of a statement of key manufacturing tasks.

A.211 The strengths and weaknesses of competitors

Each Managing Director and / or, as appropriate, Marketing Manager was asked to identify his company's major competitors. I conducted semi-structured interviews based on a proforma, shown as Attachment 1. In the interviews the Managing Directors / Marketing Managers were asked to describe the strengths and weakenesses of their major competitors.

A.212 Identification of key manufacturing policy issues which might affect competitiveness

The literature suggested that in a number of instances managing directors had limited awareness of the concept of manufacturing policy. Assuming such a lack of awareness might arise in some of the cases, I adopted an indirect approach to identifying any manufacturing policies and their influence on corporate competitiveness.

I identified the Managing Directors' perspectives about manufacturing policy issues in a two part semi-structured interview. Part one involved a list of issues drawn from the literature. I initially used a 5 point Likert type scale covering six issues and subsequently revised it to a 7 point scale and the wider set of issues shown in Attachment 2. The scale scored 7 as 'essential' and 1 as 'not important'.

I followed up the Managing Directors' scoring on the 'policies' with discussions of how the policies contributed (or not) to competitiveness. The issues were grouped into four sets to facilitate logical discussion; the design of products and physical systems of manufacture, the interaction between the plant and its facilities with marketing etc., the management system and finally, the main operational sub-systems of production.

A.213 The contribution to competitiveness from the key departments within the case studies

I identified from the Managing Directors the competitive contribution from the various functions. The assessments were made for both the current period and for 3-5 years ahead, using a Likert type scale in a semi-structured interview. The original 5 point scale again proved too limited and was revised to a 7 point system, which is shown below as Attachment 3. I compared the current and expected contributions and in the subsequent semi-structured interview sought to establish:

(a) the type of contribution made by each function
(b) the reason for any changes in the expected contribution to competitiveness

A.214 Statements of key manufacturing tasks

I sought statements of the key manufacturing tasks; where they did not exist I extended the investigation to establish those implicitly adopted in the cases. (N.B. I argued in section 3 that, regardless of whether these KMTs were well chosen or not, they represented the priorities in existence and any evaluation of the control system / approach should be gauged against such priorities or KMTs.)

The Managing Directors were asked to identify their plants' competitive priorities. To establish these priorities I asked the following five questions as part of a semi-structured interview:

(a) "Is there a written statement of the competitive features that the manufacturing plant has to achieve to enable the company to be competitive?"

(b) "If such a document exists, what areas does it cover?"

(c) "What is the process of drawing it up and which functions in the company and plant are involved?"

(d) "If there is not a written statement of your KMTs, how do you identify what is required of manufacturing?"

(e) "What is required of the "XXXXXXX" plant to make it a successful unit?"

To facilitate the discussion I prepared a list of typical KMTs based on issues raised in the literature. These were discussed with the Managing Directors using

a modified version of a technique outlined by Wheelwright (1978), see Attachment 4. As a cross check the Managing Directors were asked whether the list omitted any priorities applicable in their plants.

LIST OF 'POSSIBLE' KMTs

(a) product design
(b) manufacturing quality
(c) delivery speed
(d) delivery reliability
(e) price/cost
(f) flexibility
(g) A N other

Each Managing Director was requested to allocate 100 points to the total of current performance. He was then invited to divide the 100 points between the KMTs, in proportion to the individual KMT's relative importance in competitiveness. The exercise was repeated for different major product groups. The Managing Directors were then asked to repeat the exercise, this time allocating their 100 points to the required, as distinct from current, performance.

Based on the above data, I conducted a semi-structured interview in which the Managing Directors were asked:

(a) "Which of these performance criteria do you consider will be the most difficult to achieve over the next 3-5 years?"

(b) "Overcoming which difficulty will bring about the greatest benefit to the company?"

(c) "Are there any written standards for these performance priorities?"

(d) "To what extent is the company (marketing, stockholding, finance etc.,) aware of what achieving the performance criteria means in relation to the things manufacturing can not achieve at the same time?"

(e) "Is there any mechanism for evaluating the trade-offs that have to be made between these criteria, (i.e. the recognition that improved performance in one or more dimensions of competition will result in decreased performance in another aspect of competitiveness) and is there any means of measuring these effects?"

From a review of the overall data I drafted a statement of the Key Manufact-

uring Tasks in each of the case studies. I discussed these KMTs with the respective Managing Directors, modifying the statements as necessary until an agreed statement was achieved.

A.22 The Organisation Structure and Manning Levels in the Case Studies

Linked with the earlier identification of the Managing Directors' expectations from their departments to their plants' current and future competitiveness, I obtained copies of the organisational structure in the firms.

The data was obtained from the personnel departments. This was confirmed with the Managing Directors and cross checked by showing it to the Heads of Departments when I interviewed them on other issues.

A.221 Ratio of total employees to direct operatives

I investigated the ratio of total employees to direct production workers to check the proportion of employees performing 'controlling' activities in the cases and to establish any differences in the ratios. Data on the number of employees on the sites was obtained from personnel records, or other suitable sources, depending on the company's systems, (i.e. in one company the data was found in the work study department). I identified the following:

(a) Total number of employees on the site, (less any performing corporate activities).
(b) Number of direct production operatives (by department).
(c) Number of indirect operatives (by department).
(d) Number of staff employees (by function).
(e) Number of managers (by role).

The data on numbers of employees was confirmed in the interviews with the heads of production departments and staff functions.

A.222 Ages, service and educational attainments of the managers

I examined the age, length of service and qualifications of the top management team. These qualifications were examined for both technical and managerial subjects. Thus a designer might have engineering as his technical subject, whilst an accountant, finance etc. as his subject.

Data was obtained from the personnel departments with the aid of a proforma shown as Attachment 5. I distinguished between educational qualifications, B.A. Hons. (History) and work qualifications, HNC Production Engineering. To enable this analysis to be performed the personnel department was requested to provide information on the nature of the qualification, as well as its level.

A.23 The Managing Directors' Control Information

I decided to identify the routine reports received by Managing Directors and how they used them for control. The Managing Directors' control information was identified by the following three methods:

(a) the Managing Directors' Secretaries were asked, with permission, to intercept and record the routine control documents received by their managers.

In most instances these reports were filed by the Managing Directors' Secretaries. They were asked to record a list of these reports and to provide me with copies. The list of reports was recorded using a log, showing:

the title of the report
its frequency
its broad subject or issue covered

(b) the Heads of Department were asked to identify the reports they sent to their Managing Directors.

(c) A copy of the completed list of reports was shown to the Managing Directors, who were asked to verify whether it contained a complete record of their routine reports.

From the copies of the reports I prepared questions for a subsequent meeting with the Managing Directors. A copy of the proforma used to prepare the questions and record the data is shown as Attachment 6.

The Managing Directors' information was identified and classified in terms of its frequency, i.e. daily, weekly, monthly etc. and by its content, i.e. physical output qualities, plant utilization etc., see Figure 21 below.

Figure 21 The Classification of Reports by Topic and Frequency

Category of Performance	Daily	Weekly	Monthly
Physical quantities			
Plant utilization			
Plant load / schedule			
Labour performance			
Stocks and WIP			
Quality			
Financial			
Sales and delivery			
Total			
Number of reports			

The Managing Directors were interviewed using a semi-structured interview in which I sought answers to the following questions:

(a) how the information was used
(b) was the information for regular decision making or normally for background guidance
(c) was there a particular part of the report that was important
(d) were standards available to gauge performance
(e) was the FREQUENCY of the information right for the decisions that had to be undertaken
(f) was the CONTENT covering the desired issues
(g) was the FORMAT or presentation suitable for their use
(h) did the TIMING of the presentation match their points of decision making
(i) did their subordinates receive the same information and upon which aspects of performance did they want them to concentrate
(j) what figures/trends/ratios caused them to highlight the need for improvement

On completion of the first stage of the interview, (dealing with the known formal reports), the Managing Directors were asked two open-ended questions:

firstly to identify their priorities of control and secondly to establish whether there were any major approaches to monitoring / controlling production performance, which were not shown by the questions relating to the formal reports received.

The Managing Directors were asked:

"What is the most important information for your control of the plant?"

This was followed up by asking:

"In what other ways do you attempt to maintain control over the production function?"

A.24 The Production Management Team's Information

Data was collected on the routine information received by the Production Managers and their subordinates. The methods used were similar to those for Managing Directors in section A.23 above, the only difference being an additional question on their superior's receipt of similar information.

"Does your immediate superior directly receive any of these reports? If so, which and are there any figures / ratios which you would expect to trigger his taking action?"

Where the Production Manager had a Secretary, she was asked to collect a specimen set of his control reports, while where one did not exist, the Managers were asked to select their own documents. In both situations, cross references were made with the heads of other departments to check whether other documents were prepared and had been inadvertently omitted by the recipients. The Managers were questioned on their use of the reports, using the same questions as for the Managing Directors, see Attachment 6.

A.25 The Use of Production Meetings in the Control Process

To identify the role of the production meetings in the control process, recordings of their timings, frequency and content was made.

The routine production meetings, (at Production Manager and Superintendent level), were established. This was accomplished by:

(a) Asking the Production Managers' Secretaries, (where these existed), to list all their Managers' meetings.

(b) The Managers were themselves asked to confirm their attendance at these meetings and to add / delete any meeting not covered.

The frequency of the meetings was then summarized and their detailed conduct was also examined. I did this by attending representative meetings and I identified the content by recording the topic of the meeting at one minute intervals. The results were then analysed to give the percentage of time devoted to the various topics in the meetings.

A.26 Investigations into Failures to Accomplish Control of Performance

I examined the records in the cases to identify whether the plants concerned were delivering the production on time, achieving their planned levels of output and meeting the quality standard, both as dispatched to customers and internally in terms of yield rates. I also cross checked whether production was within the planned budget levels. In most instances I was able to obtain at least one year's historical records for my analyses.

A.261 Delivery reliability

I checked delivery reliability by examining dispatch records and comparing them with the promised delivery dates. Where the volume of data was particular-

ly high, I sought cooperation from company staff to select sample data. I asked the Dispatch or Sales Office Managers to draw the sample from representative products and customers. I used this approach because the data so obtained was found to be more acceptable to senior managment in later discussion on reasons for any shortfall in performance.

I wrote a computer programme using the dBase II package to identify any products which had particularly high levels of lateness.

A.262 Quality and yield levels

Data on dispatched quality was primarily obtained from customers' warranty claims and finished goods' inspection records. Data on yield levels was obtained from inspection records and cross checked with production control records. In the latter records I examined the quantities released to production and compared them with the completed output levels. In some instances I undertook analyses of the rejects of first-off components offered to inspection and of the rate of rejects by patrol inspectors. Such studies were triggered by problems identified in the individual case studies.

I entered the above records in a computer programme which I wrote using the dBase II package. This was used to separate any differences in the level of rejects by product type.

A.263 Cost control

I established whether costs were under control by inspection of the cost records. My primary concern was the issues controllable by production, so I did not investigate adverse overhead variances or material price variances. I concentrated on material usage and labour performance and the levels of WIP in

the plant. In most of the cases the plants used standard costing systems which made the records about individual product variances subject to usage and rate variations. Where this occurred I concentrated on the time based variable as being more under the control of production management.

A.27 Identifying Production Managers' Preferred Sources of Information

I identified the Production Managers' preferred sources of information via a questionnaire, shown in Attachment 7. The questionnaire was administered to all Production Managers and Supervisors. The identification of the ranking of these sources of information was followed up with an examination of the actual practices of the Production Managers and Supervisors, particularly in terms of written reports, touring the plant and the use of meetings.

A.3 THE PART TWO RESEARCH PROCESS

The part two method of study reflected a number of lessons learnt in the part one investigation. These had led to a new understanding of the importance of the revised paradigm to the control of production. It became necessary to put aside a number of other interesting ideas in order to more fully concentrate on the above theme. I used the second stage of the study to modify the means of investigation. My principal aim was to simplify the identification of the way the plants were competing and to increase the clarity with which production's role was specified. I was able to achieve part of this simplification by using a method of identifying order winning criteria developed at that time by Hill.

A.31 Identifying the Basis of Competing in the Case Studies

I modified the original list of issues to discuss with the Managing Directors, as shown above in section A.21, based on my use of the earlier investigations. The

revised list was in five parts. The interviews used the semi-structured questionnaires shown as Attachment 8. This instrument covered the following:

(a) the plant's strategy and key tasks
(b) manufacturing's key tasks in supporting competitiveness
(c) competitive priorities for a range of products
(d) identifying the principal competitive goals for production
(e) the Managing Director's control information

The information was gathered from the Managing Directors in a series of meetings which I was able to tape record for more accurate review and analysis.

A.311 The plants' strategic key tasks

The interview identified whether the plants possessed corporate planning systems and if they did, whether these included specific written plans which harnessed manufacturing performance as a basis of competitiveness. I followed up the theme of 'written plans' with a series of questions aimed at establishing what the Managing Directors perceived as the key tasks of their manufacturing functions.

A.312 Establishing competitive priorities; identifying the OWC

Details of the semi-structured interview used in establishing the competitive priorities are shown below in Attachment 8. I used a modified version of Hill's order qualifying and order winning criteria technique. To assist the Managing Directors I provided them with a prompt list of possible OWC, as in Wheelwright's method (see part one above). They were invited to select 3-5 representative products and then to give their evaluations of the OWC for these products in the current and in two, self selected periods in the future.

A.313 Achieving the competitive goals

Having established with the Managing Directors what they considered to be their plants' key competitive tasks, the interviews then examined these tasks for their levels of difficulty and the magnitude of the benefits they expected to receive from their successful accomplishment.

A.314 Identifying the managing directors' perspective of contribution to competitiveness from functions.

I established the Managing Director's perspective of the strategic contribution to competitiveness from each of the main departments using the same methods as in part one, see Attachment 3. However, I modified the follow up questions to establish the link, if any, which they saw between the OQC / OWC and the departmental contributions to competitiveness.

These interviews were also tape recorded to enable more accurate review. The process was repeated asking the Managing Directors what they anticipated the contributions to competitiveness from these functions would be in 3-5 years time. During this exercise the Managing Directors were asked whether their companies had corporate strategies and if there was a manufacturing component to such a strategy. Where this did not exist, they were asked to identify the major elements in manufacturing's role in the company's plans for competitiveness.

Based on the data received from the methods outlined above, I prepared a written statement of my interpretation of the key manufacturing tasks. This was shown to the respective Managing Directors and modified as necessary.

A.32 Linking the Managing Directors' Control Information with their Goals

Having established the Managing Directors' perspective of their plants' major

competitive tasks, I subsequently used this information when evaluating the relevance of their control information.

The aim was to establish how the Managing Directors controlled their manufacturing functions. I included an examination of the balance they made between their own control efforts and those of the executive responsible for manufacturing / production.

I collected samples of all the information / control reports they received. The only exceptions to this were:

(a) limited access to the full accounts
(b) " " " " monthly reports of the functional heads

I used the same method of collection and classification of the reports as in the part one study. In addition I added a series of questions, see Attachment 8, aimed at discovering whether they received sufficient analysis in these reports or whether they were primarily summaries of lower level data. Other questions sought to explore what they considered to be their most effective means of controlling production and what they considered to be their greatest difficulties in achieving control of production. My final area of investigation with the Managing Directors was to identify their views on the relative priority production managers should give to achieving compliance to standards compared, with making incremental improvements to the manufacturing system.

A.33 Establishing the Functional Heads' Perspectives of Order Qualifying / Winning Criteria

The examination was limited to the central providers of control information and / or those who would / could contribute significantly to systematic improvement of the plant's performance. This stemmed from the purpose of identifying whether those who have a major influence on controlling or improving production performance are working on a consistent set of priorities. The examination

attempted to get these functional heads to differentiate between what their department's contributions should be, and what affects the plant as a whole.

The major information providers in general were:

Accounts
Work Study
Production Control

The major sources of improvement came in general from:

Production Engineers / Process Engineers / Ceramicists
Work Study / Industrial Engineers.

In some instances the Marketing Manager's perspectives on order qualifying / winning criteria were obtained. This was done where either the Managing Directors expressed doubt on the criteria, or where there were substantial differences in the perspectives of the Managing Directors and their respective Production Managers. The procedure used was the same as for the Managing Directors using re-titled versions of Attachment 8.

A.34 Establishing how the Manufacturing Directors Controlled their Production Units

The purpose of this section was to establish the following:

(a) What they saw as their most important tools in controlling production performance

(b) What control information they received on a routine basis

(c) What, if any, exception reports they received

(d) How they used the information

(e) How they evaluated the information in terms of frequency, content, format and timing

(f) The level of duplication in the control information between superiors and subordinates

(g) How the Manufacturing Directors rated the written control information compared with other sources of information

(h) How the Manufacturing Directors used meetings to control the plant

(i) What proportion of their time was devoted to routine meetings and an estimate of their time spent on non-planned meetings

(j) The Manufacturing Directors' perspective of OQC/OWC

(k) How the Manufacturing Directors perceived the balance between control to standards and systematic incremental improvement

To establish answers to the above topics I used a series of semi-structured interviews with the most senior managers on site directly responsible for manufacturing, see Attachment 9.

A.35 The Production Managers' sources and use of control information

The purpose of this stage of the research was to establish the following:

(a) What control information did the production managers / supervisors receive on a routine basis

(b) What, if any, exception reports did they receive

(c) How did the production managers / supervisors use the information

(d) How did they evaluate it in terms of frequency, content, format and timing

(e) What level of duplication was there in the control information between superiors and subordinates

(f) How did they rate the written control information compared with other sources of information

(g) How did they use meetings in the control of the plant

(h) What proportion of their time was devoted to routine meetings and un-planned meetings

(i) The production managers' perspectives of OQC and OWC

(j) How did they perceive the balance between control to standards and systematic incremental improvement

A.36 Evaluating the Cases' Adoption of the Dimensions of the Revised Paradigm

Four dimensions were identified as having significant effects on the degree to which the case studies adopted the revised paradigm. These dimensions were converted into the scales used in Figure 16. I developed the scales shown below and then classified the extent to which production management, in each of the case studies, adopted the styles of managing shown in them.

A.361 Strategic - tactical dimensions

1. Production management limits its attention to a narrow sub-set of performance criteria, which conflict with the priorities in the plant's corporate strategic goals.

2. Production management concentrates on a limited sub-set of the manufacturing based OWC / OQC. Some major criteria are either omitted or significantly under-emphasised.

3. Production management attempts to do well on all its OWC / OQC. It does not, however, differentiate between the criteria in terms of its priorities and thus trade-offs.

4. Production management seeks high performance in all its OWC / OQC, recognizing the impact of its trade-offs on each other and reflecting the company's corporate position in these trade-offs.

5. Production management provides the plant with a major competitive advantage through its ability to consistently accomplish more difficult manufacturing tasks.

A.362 Integration - fragmentation dimensions

1. Individual functions consistently pursue their own functional goals which conflict with the plant's KMTs / OWC. Major conflicts between the goals of the individual functions and production are common.

2. Individual functions tend to pursue their functional goals which are not closely matched to the KMTs / OWC. Minor conflicts occur between the goals of the functions and with production management.

3. Individual functions work effectively to foster control and improvement of production performance. The individual functional priorities tend to deviate slightly from the KMTs / OWC.

4. No formal system exists to ensure integration of effort; however, all major functions informally cooperate with each other and production to achieve control and improvement in line with the KMTs / OWC.

5. The plant has a formal system designed to integrate the work of the functions with production management to obtain control and improvement of manufacturing performance in line with the KMTs / OWC.

A.363 Intermittent - continuous dimensions

1. No significant improvement projects directly involving production management have been completed in the past two years.

2. At least one improvement project directly involving production management has been completed in the last two years.

3. A number of improvement projects directly involving production management have been undertaken in the last two years.

4. Regular improvements in production performance are expected and obtained directly from efforts made by production management. Sufficient projects exist to ensure that there is always at least one active project in hand at any one time.

5. A major formal programme of continuous improvements in production performance, directly resulting from efforts made by production management, has existed for two or more years.

A.364 Stepped - incremental dimensions

1. No identifiable incremental improvements could be traced to production management.

2. Small number of incremental improvements accomplished by production management in past two years. These improvements concentrate primarily on labour savings. There is no identifiable link between the incremental improvements and staff led changes. However, minor evidence of conflict between the two is detected.

3. Several incremental improvements to production performance have been accomplished in the past two years. The improvements concentrate primarily on costs, and are not strongly integrated with the KMTs / OWC. There is no identifiable link between these improvements and staff led step changes to the manufacturing system.

4. A wide range of incremental improvements has been made in production performance over the past two years. Several of these improvements are integrated with staff led step changes.

5. Production management's incremental improvement of the operating system is a critical part of the formal system for the control of production. The incremental improvements are coherent with the strategy for manufacturing and provide a basis for stepped changes introduced by staff.

A.37 Development of Ishikaw Diagrams of Order Winning Criteria

I identified the factors most likely to require effective control and / or improvement in order to achieve the respective plant's order qualifying / order winning criteria.

The aim as noted above was to ensure that the test of the link between control information and the OQC / OWC was solidly founded on the real needs and problems facing each plant. The process used was to construct a theoretical Ishikaw diagram for the two largest production based OWC in each plant. The

diagrams were based on the concepts of control, as covered in leading POM texts etc.

The completed diagrams were then presented to the Production Manager to check whether they covered the important practical factors affecting the aspects of the plant's performance needing control, if the OWC were to be met. This analysis was then extended and used as the basis of the checks on whether the company had:

(a) control measures / exception reports on these dimensions of performance
(b) any programmes or actions to bring about improved performance.

The diagrams also provided a basis for the analysis of the physical performance of the 12 months prior to the fieldwork and acted as a cross check for the monthly reviews of control / improvement in the 6 months of fieldwork.

A.38 Analysis of the Physical Performance of the Plant in the 12 Months Preceding the Fieldwork

I examined the plants' records of physical / cost performance related to achieving the two main, production based, OWC. Some plants did not have such records on these key themes or had not retained the records that they had initially made. These facts about the availability or not of information are incorporated in the review.

This investigation exposed the controlling / improving activities of the Production Managers. The intention was to identify what they sought to control / improve, why they concentrated on those aspects of performance, what means they used in attempting this control / improvement and to identify any factors which either facilitated or hindered their actions.

The review sought specific examples of the following:

(a) examples of more effective control

(b) examples of improved performance, particularly due to changed means of obtaining the results
(c) examples of new / additional / refined sets of reports / information, including any exception reports
(d) examples of new / improved means of analysing the information available, which included both their own analysis and that provided by specialist staff
(e) examples of any trials or experiments, including unsuccessful trials, aimed at improving control / performance

A.39 Analysis of the Knowledge / Skills of POM Staff Compared with their Peers in the other Functions

The purpose of this section was twofold:

(a) to establish the comparative educational (general) and managerial (specialist) level of knowledge in the various functions, in order to compare that in POM with their peer levels.

(b) to identify where the POM staff got any updating knowledge / skill related to their specialist activities.

My aim was to relate the effectiveness of the efforts to control / improve to the level and quality of the knowledge of POM staff. The data was collected via a questionnaire shown as Attachment 10.

ATTACHMENT 1

Product group.....

The strengths and weaknesses of "....." as seen by the Managing Director of the "....." plant.

COMPETITOR STRENGTHS	COMPETITOR WEAKNESSES

The strengths and weaknesses of "....." as seen by the Managing Director of the "....." plant.

COMPETITOR STRENGTHS	COMPETITOR WEAKNESSES

(The questions were repeated to cover all the competitors identified by the Managing Directors and Marketing Managers)

ATTACHMENT 2

RANGE OF POSSIBLE ISSUES REQUIRING THE USE OF SPECIFIC MANUFACTURING POLICIES

Please tick in columns 1 to 7, as appropriate, your assessment of the contribution of the following issues to your plant's competitive performance.

SUBJECT	DEGREE OF IMPORTANCE NOT 1	SL'TLY 2	MILDLY 3	MOD LY 4	FAIRLY 5	VERY 6	ESS'L 7
PROD.DESIGN/ DEVELOPMENT							
PROD.FOCUS/ VARIETY							
MAKE & BUY DECISIONS							
(1) PRODUCTS							
(2) COMPONENTS							
INVESTMENT IN PLANT							
INNOVATION IN PROD.TECHS.							
FLEXIBILITY							
(1) NOVEL DESIGNS							
(2) PRODUCT MIX							
(3) QUALITY LEVELS							
(4) VOLUME/OUTPUT							
(5) DELIVERY TIMES							
STABILITY IN WORK LOAD							
EXPERIENCE CURVES							
RESTRUCTURING OF ORGANIZATION							
QUALITY							
(1) PRODUCED							
(2) DESPATCHED							
MAT'L/INVENTORY							
(1) PURCHASING							
(2) HOLDING INVT.							
SCHEDULING							
(1) THROUGHPUT TIME							
MANPOWER COSTS							
(1) DIRECT							
(2) INDIRECT							

ATTACHMENT 3

THE MANAGING DIRECTOR'S EXPECTATION OF CONTRIBUTION TO CURRENT COMPETITIVENESS FROM THE INDIVIDUAL DEPARTMENTS

Please tick in the appropriate column your assessment of each of the following department's contributions to your plant's current competitiveness.

	DEGREE OF IMPORTANCE							
	NOT	SLIGHTLY	MILDLY	MODERATELY	FAIRLY	VERY	ESSENTIAL	
PRODUCTION								
PROD'N CONTROL								
QUAL'Y CONTROL								
WORK STUDY								
FINANCE								
SUPPLIES								
DESIGN								
WORKS ENG.								
PERSONNEL								
OTHER (SPECIFY)								

* A second questionnaire was then used, repeating the questions for the departments "expected contribution in 3-5 years time".

(N.B. On completion of each of the questionnaires, I asked the Managing Directors to describe the nature of the contribution to competitiveness made by the departments listed.)

ATTACHMENT 4

KEY MANUFACTURING TASKS

Please complete the following survey:

a. Check that the list of key manufacturing tasks represents the issues that are important to your plants' competitiveness. If it does not, please revise the list as necessary.

b. Starting with product group 1, allocate points to each of the items in the list of key manufacturing tasks in proportion to their current achievement in supporting competitiveness. The total of all the points should equal 100.
Please repeat the exercise, this time allocating the points according to the required level of achievement to achieve optimal competitive performance.

c. Please repeat the exercise for current achievement and required achievements for product group 2.

	PRODUCT GROUP 1		PRODUCT GROUP 2	
KEY MANUFACTURING TASKS	CURRENT ACHIEVEMENT	REQUIRED ACHIEVEMENT.	CURRENT ACHIEVEMENT	REQUIRED ACHIEVEMENT
PROD. DESIGN				
MANUFACTURED QUALITY				
PRICE/COST				
DELIVERY RELIABILITY				
DELIVERY SPEED				
FLEXIBILITY				
OTHER				
TOTAL	100	100	100	100

ATTACHMENT 5

Please complete the following proforma, using the notes at the bottom of the page for guidance.

THE AGE, SERVICE AND EDUCATIONAL ATTAINMENTS OF MANAGERS

MANAGEMENT FUNCTION	AGE	SERVICE	EDUCATIONAL AND TECHNICAL ATTAINMENTS
Managing Director			
Prod'n. Eng.			
Works Eng.			
Quality Manager			
Works Manager			
Personnel Manager			
Admin.			
Production Control Manager			
Work Study Manager			
Prod'n. Mgr 1.			
Prod'n. Mgr 2.			
Superintendent 1.			
Superintendent 2.			
Arithmetic Av.			

Notes.

1. Age: please give each manager's current age (years only).

2. Service: please give the manager's total number of years service with the company. When service is over 2 years, please give years only, if less than two years, please give the number of months as well.

3. Educational and technical attainments: please list each manager's educational and technical attainments with dates and identify any non-qualification courses he has attended in the last two years. The list of attainments should identify the courses as follows: BSc. Hons. Chemistry, HNC Mechanical Engineering.

(N.B. The list of positions had been defined earlier from the organizational structure provided by personnel and cross checked with the Managing Director)

ATTACHMENT 6

SUMMARY OF WRITTEN CONTROL INFORMATION EXHIBIT No

Received by ..... Issued by .....

Frequency (please tick) DAILY / WEEKLY / MONTHLY / OTHER (please specify)

TYPE OF CONTROL INFORMATION

General description

USE OF INFORMATION

Does the information in this report meet your requirements in respect of its **CONTENT** ? If not, what changes would you wish to make ?

Does the information in this report meet your requirements in respect of its **FORMAT** ? If not, what changes would you wish to make ?

Does the information in this report meet your requirements in respect of its **TIMING** ? If not, what changes would you wish to make ?

Does the information in this report meet your requirements in respect of its **FREQUENCY** ? If not, what changes would you wish to make ?

What figures, if any, are likely to trigger corrective action ? Are there any specific standards for these trigger points ?

SUMMARY OF WRITTEN CONTROL INFORMATION EXHIBIT No

Received by ..... Issued by .....

Frequency (please tick) DAILY / WEEKLY / MONTHLY / OTHER (please specify)

TYPE OF CONTROL INFORMATION

General description

USE OF INFORMATION

Does the information in this report meet your requirements in respect of its **CONTENT** ? If not, what changes would you wish to make ?

Does the information in this report meet your requirements in respect of its **FORMAT** ? If not, what changes would you wish to make ?

Does the information in this report meet your requirements in respect of its **TIMING** ? If not, what changes would you wish to make ?

Does the information in this report meet your requirements in respect of its **FREQUENCY** ? If not, what changes would you wish to make ?

What figures, if any, are likely to trigger corrective action ? Are there any specific standards for these trigger points ?

ATTACHMENT 7

THE QUESTIONNAIRES ON LINE MANAGERS' VIEWS ON KEY ISSUES TO BE MONITORED

Please score the following questions in RANK ORDER with 1 as the most important source of information and 6 as the least important source. (The sixth category of a free choice is provided to enable you to add in any sources of information you consider important and which are not included in the formal questions.

THE SOURCES OF INFORMATION FOR MONITORING MANUFACTURING PERFORMANCE

Source of information	Rank
Written reports and information, from all sources	
Information gathered from personal contacts you initiate within the firm	
Information gathered from your physically touring the plant.	
Information gathered at formal meetings chaired by production personnel.	
Information gathered at formal meetings chaired by non-production personnel.	
Other sources (monthly management meeting)	

ATTACHMENT 8

Statement
The primary purpose of this interview is to establish the means by which manufacturing can most effectively contribute to your firm's competitiveness. The starting point is the way in which the firm qualifies for, and then goes on to win, orders. It then asks about the roles played by the functions in achieving competitiveness and finally about the educational / training levels of the senior functional management.

PROCESS OF IDENTIFYING THE PLANT'S KEY MANUFACTURING TASKS

1. Does your firm use a formal system of corporate planning ?

YES NO

2. If YES, can I see a copy of the plan as it relates to the goals required of production ?

3. If no plan exists, what are the main aims of your company over the next few years ?

4. What do you, as the senior Director responsible for the site, identify as the KEY MANUFACTURING TASKS?

In terms of this plant what are the major competitive priorities to which manufacturing has to address itself?

(a) Is there a written statement of the competitive features that the manufacturing plant has to achieve to enable the company to be competitive?

(b) If such a document exists, what areas does it cover?

(c) What is the process of drawing it up and which functions in the company and plant are involved?

(d) If there is not (a written KMT), how do you identify what is required of manufacturing?

(e) What is required of the PLANT to make it a successful unit?

5. Key manufacturing tasks

(a) Cost control
How much of the cost performance required for competitiveness can come from production management's meeting existing performance standards? Similarly, how much must come from bringing about changes in the systems, products and processes used?

(b) Availability / Delivery performance
How much of the delivery performance required for competitiveness can come from production management's meeting existing performance standards? Similarly, how much must come from bringing about new methods in the systems, products and processes used?

(c) Quality
How much of the quality performance required for competitiveness can come from production management's meeting existing performance standards? Similarly, how much must come from bringing about changes in the systems, products and processes used?

Review of the "distinctive contributions to competitiveness"; i.e. what aspects of the summary provided earlier need revision, in the sense of the departments' strategic contribution to the firm's competitiveness?

ESTABLISHING COMPETITIVE PRIORITIES

Ranking competitive priorities

6. Please identify 3-5 representative products and list their competitive priorities. As your company may operate in several product markets, with differing market place priorities, please check that all significant markets are covered in the product selection. For each of these products I would like you to to assign your current weightings to these priorities, so that they total 100%. Next please identify how you see these priorities changing in the near future. Please specify two future time periods, related to the product life cycles of your business, and review the weightings.

   In the first instance please do not use the 'prompt' list below. If you subsequently wish to, you can use the list as a cross check on the completeness of the answer. Does the list omit any priorities applicable to the 3-5 representative products from your plant's product range?

   (a) product design
   (b) manufacturing quality
   (c) delivery speed
   (d) delivery reliability
   (e) price/cost
   (f) flexibility
   (g) A N other

ORDER WINNING CRITERIA

Product:

Priority	1985 percentage	198- percentage	19-- percentage
TOTAL	100	100	100
VOLUMES			

Product:

Priority	1985 percentage	198- percentage	19-- percentage
TOTAL	100	100	100
VOLUMES			

ACHIEVING THE COMPETITIVE GOALS

7. (a) Which of these performance criteria do you consider will be the most difficult to achieve over the next 3-5 years?

7. (b) Overcoming which difficulty will bring about the greatest benefit to the company?

7. (c) Are there any written standards for these performance priorities ?

7. (d) Please identify any areas where manufacturing has to provide **order qualifying performance.**

7. (e) Are there any aspects of the **order qualifying** criteria, which you expect to change in the realizable lifetime of the product? If so, how are these likely to affect the type of manufacturing system needed?

7.(f) Do you consider there to be any **order qualifying** criteria, which could become **order winning** criteria? If so, what are the manufacturing implications?

7.(g) Are there any criteria which you consider might become **order losing** criteria?

Summary of the KMTs

A written summary of the KMTs as interpreted by the researcher will be produced and subsequently reviewed and discussed with you.

LINKING CONTROL INFORMATION WITH THE COMPETITIVE PRIORITIES

8. **Measuring manufacturing performance**

What control information do you receive, which tells you about production performance?

Daily
Weekly
Monthly etc.

In particular, what types of trend information do you keep?

9. Does anyone (manufacturing or finance etc.) provide an analysis from the information?

10. How do you control the manufacturing function? Please describe the way in which you do this, in terms of both routine and exceptional reports, meetings, informal contacts etc.

10.(a) What are the most important and effective tools at your disposal for controlling manufacturing?

10.(b) Where do you find the greatest difficulty in achieving control? (What factors most frequently hinder your achieving the desired level of control)?

11. Within the specifically PRODUCTION function of manufacturing, where do you see the main efforts should be focused to make control contribute to the plant's competitiveness?
(i.e. What are the most difficult things, and the most important things, for production management to control?)

12. Taking the performance areas identified above, to what extent do you expect:

(a) Production to concentrate on meeting specific performance standards - by concentrating on corrective action?

(b) Production to liaise with other functions in bringing about changes to the systems/technology to get rid of (overcome) the problems leading to ineffective control?
i.e. changes in complexity, uncertainty or similar concepts.

(c) Production to take a specific (proactive) role in bringing about small (incremental) changes to systems and processes, which push back the frontier of control or tackle the trade-off areas of higher quality and lower costs, better delivery and lower inventory?

Please give specific examples of **both** achievements in any of the above over the last 12 months **and** the way in which you make this occur!

ATTACHMENT 9

Questions for Senior Production Managers

How do you control the manufacturing function? Please describe the way in which you do this in terms of reports, both routine and exception, meetings, patrols around the plant and informal contacts etc.

(a) What are the most important and effective tools at your disposal for controlling manufacturing?

(b) Where do you find the greatest difficulty in achieving control; (what factors most frequently hinder your achieving the desired level of control)?

Within the specifically PRODUCTION function of manufacturing, what are the main priorities? i.e. where should efforts be focused to make the control of production contribute to the plant's competitiveness?

What do you consider to be the most difficult things for production management to control?

Taking the performance areas identified in 2 above, to what extent do you expect:

(a) Production to concentrate on meeting specific performance standards - by concentrating on corrective action?

(b) Production to liaise with other functions in bringing about changes to the systems / technology to get rid of (overcome) the problems leading to ineffective control?
i.e. changes in complexity, uncertainty or similar concepts.

(c) Production to take a specific (proactive) role in bringing about small (incremental) changes to systems and processes, which push back the frontiers of control or tackle the trade-off areas of higher quality and lower costs, better delivery and lower inventory?

Please give specific examples of **both** achievements in any of the above over the last 12 months **and** the way in which you make this occur!

How do you measure manufacturing performance?

What control information do you receive, which tells you about production performance?

Daily
Weekly
Monthly etc.

In particular, what, if any, types of trend information do you keep?

Does anyone (manufacturing or finance etc.) provide an analysis from the information?

KEY MANUFACTURING TASKS

Cost control
How much of the cost performance required for competitiveness can come from production management's meeting existing performance standards?

Similarly, how much must come from bringing about changes in the systems, products and processes used?

Availability
How much of the delivery performance required for competitiveness can come from production management's meeting existing performance standards?

Similarly, how much must come from bringing about changes in the systems, products and processes used?

Quality
How much of the quality performance required for competitiveness can come from production management's meeting existing performance standards?

Similarly, how much must come from bringing about changes in the systems, products and processes used?

Is there a specific 'improvement plan' for production? If so, what role do you expect production management to play in it? Is their role to support the staff efforts to achieve improvements or do they themselves have a specific 'direct' contribution to make? Please give concrete illustrations.

Are there any changes which you would like to make in the way in which production management seeks to control?

Changes in:

Information

Responsibilities (structure)

Their concept of their role

Skill levels etc.

ATTACHMENT 10

Private & Confidential

I would be grateful for your help in completing this questionnaire. It is about identifying the most important aspects of production performance to control and improve. It also asks about your sources of information and how you use them control and / or improve production. The completed questionnaires will be treated in confidence and only be seen by myself and my research supervisor. The thesis will disguise the data so that neither the Company or you can be identified. Please complete all sections as fully as possible, if you have nothing to record, please enter "NO INFORMATION".

Biographical Data

Name ..... Age .... Yrs .... Months

Job Title ..... Date joined Company ../../..

Date appointed to current position. .. /../..

The major items to control and improve

1. What are the most important aspects of the production department's work to control ? Please list in order of decreasing importance (Control, is used in the sense of making certain that the planned level of performance is achieved)

(a)
.....

(b)
.....

(c)
.....

(d)
.....

2. What are the most important aspects of the production department's work to improve ? Please list in order of decreasing importance

(a)
.....

(b)
.....

(c)
.....

(d)
.....

Training and Education

3. Please list any training or educational courses you have attended, in the past two years, related to either the technical or managerial aspects of your work. PLEASE include any in-company training sessions.

TITLE / OR DESCRIPTION OF COURSE	WHERE ATTENDED	LENGTH DAYS/MONTHS	DATES FROM	TO
(a)				
(b)				
(c)				
(d)				
(e)				

4. Do you have any qualifications, other than those outined above ? If so, please identify them below.

TITLE OF QUALIFICATION	AWARDED BY	DATE
(f)		
(g)		
(h)		

5. Which, if any, of the above courses / training sessions or qualifications has most helped you in performing well as a production manager/supervisor?

.....

.....

.....

.....

6. Do you attend any meeting of professional institutions, which provide ideas on how to manage production ? If yes please give details.

.....

.....

.....

7. Do you regularly receive any journals etc, which help you in your work ?

TITLE OF JOURNAL / MAGAZINE	HOW OFTEN RECEIVED	WHO SENDS IT

8. Have you in the last two years, undertaken either on your own or with others, any trials or experiments, designed to either increase the level of control or improve production performance? Please give relevant details.

.....

.....

.....

.....

.....

Training and Information changes

9. Are there any types of course or subjects that you would like to learn about, which you consider likely to help you do your job more effectively ?

.....

.....

.....

.....

.....

10. Are there any aspects of your job where you consider you would be likely to control better or improve production performance, if you received either better or additional information. Please do not limit your answer to only cover written reports.

.....

.....

.....

.....

.....

11. Has the level of control you have achieved over production, been affected in the last two years, by changes in any of the following.

Please delete part that is not applicable.	LEVEL OF CONTROL IS Much Better	Little Better	Same	Little Worse	Much Worse
increase/decrease in variety of end products					
increase /decrease number of parts					
tighter/ looser product specifications					
improved/declined worker skills					
improved/declined worker attendance					
improved/worsened plant condition					
simpler/sohpisticated type of equipment					
steady/ variable scheduling of work load					
even /uneven product mix					
any other system changes					

12. Which, if any, of the above changes have been introduced by production management, with the intention of achieving better control of production performance ?

.....

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.....

.....

13. What sources of information have been most helpful in making the changes for the better ?

.....

.....

.....

.....

.....

Control information

14. What do you consider to be your most important sources of information to control and improve production performance? Please score control and improvement independently, ranking each in order of their own importance, 1 = highest, 6 lowest.

THE SOURCES OF INFORMATION FOR MONITORING MANUFACTURING PERFORMANCE

Source of information	Controlling Performance	Improving Performance
Written reports and information, from all sources		
Information gathered from personal contacts you initiate within the firm		
Information gathered from your physically touring the plant.		
Information gathered at formal meetings chaired by production personnel.		
Information gathered at formal meetings chaired by non-production personnel.		
Other sources		

APPENDIX B - ILLUSTRATIVE SETS OF CONTROL AND IMPROVEMENT REPORTS

B.1 INTRODUCTION

Given the weaknesses in the control reports and the inadequate analysis in all the cases, I considered that it was necessary to provide a few examples of the type of alternative reports which could support greater learning and improvement, whilst controlling production performance.

The revised paradigm enables management to achieve a state of control in production while accomplishing more difficult manufacturing tasks, which increase the firm's competitiveness. This is achieved by controlling complexity while enhancing competence and reducing uncertainty. The first phase entails reducing uncertainty and improving manager / worker competence. During this phase system complexity is limited or even reduced. When the benefits of uncertainty reduction and greater competence are felt, new and more complex tasks can be accommodated, without loss of control. All three elements, uncertainty, complexity and competence require strategic direction so that, together, they enable production to achieve strategically important, but difficult, manufacturing tasks.

Schonberger (1986) encourages the measurement of customer oriented dimensions of performance such as quality, cost, lead time and flexibility. He is critical of the over emphasis on efficiency in most internal reporting systems. However, he indirectly points to other measures which reflect the level of variability (uncertainty) in the manufacturing system. Widening Schonberger's argument, new measures can be developed indicating the plant's likely future competitiveness by examining trends in competence, complexity, uncertainty etc. The illustrative reports which follow reflect both OWC and the intermediate 'levers of control'. It is important to recognize that the control information generated in them should be interpreted as a whole and in the context of each case's strategic manufacturing aims. If one or more measures were pursued without due regard to the overall strategic goals, the effect could be an imbalanced state of control.

Although my research has shown the need for better information to help formulate strategy, I limit my review to routine control of strategic issues to avoid deviating into the formulation of manufacturing strategy. While the issues I consider below are strategic, it is necessary to recognize that my emphasis is its execution, not its formulation. In some instances I was unable to use data from the case studies because the firms did not collect key data. In these instances I provide forms without data, but with headings, to indicate what should have been produced.

The need for better monitoring of performance on OWC issues has been emphasised many times in recent years. Despite this recognition, both my own and the research of others has shown that these issues still receive inadequate attention. For the sake of brevity I limit the reports to those not dealt with by conventional techniques of monitoring, particularly labour, as these are well covered in conventional POM literature. (I remind the reader of the application I made of CUSUM techniques to labour performance in the brakes case.)

If the changes in the information suggested below were produced by staff functions, they would probably be too expensive. However, the following suggestions are based on the data being collected and examined by production management and workers, as part of a programme for systematic improvement. Unless those who have to take the corrective actions in production are involved in the process of collection and analysis, the full potential of the improvement programme is unlikely to be achieved.

B.2 MEASURING DELIVERY PERFORMANCE

Delivery reliability was shown to be an important OWC in all cases, and yet, as New & Meyers found, only 50% of firms in a large scale self-reporting study

claimed that it was measured. My study, which asked for evidence of such measurements, was unable to find a single example in which delivery was directly monitored. At its best delivery was monitored via back-order reports or customer complaints of lateness.

A second dimension of delivery, applicable to 'make to order' production, is the lead time. Even where making to stock is possible, because of the standardized nature of the product, some firms will for cost reasons wish to make to order. The impact of modern manufacturing techniques, both FMS and JIT, has led to significantly reduced lead times. Thus, making to order with rapid delivery is now practical for some firms. Although in some ways a measure of delivery, I deal with lead time measurement under the sub-section on flexibility. It is thus clear that delivery performance is both important and largely unmeasured. Unless this weakness is overcome, firms cannot reasonably expect to be fully 'in control', let alone competitive as suggested in the revised paradigm.

8.21 Measuring Delivery to the Customer

I noted above that 'on time' delivery was a largely unmeasured OWC. In a number of the cases it would have been easy to comprehensively monitor delivery by modifying the order entry systems. Senior management could have then been provided with reports showing the proportion of products delivered early, on-time, late etc. More subtle analyses such as the percentage of items, rather than orders, and differences in the delivery achievements between product lines, could also have been produced. While computers would help in making such analyses, manual methods were still practical. Tables 28 and 29 below demonstrate the type of information produced, in the kitchen furniture case, using samples of the orders processed per month. They give a clear, if not complete, view of performance.

Table 28 Example of Delivery Performance Analysis
(Data drawn from records by Sales Office Manager)

Summary of despatch records
(sample of 543 orders)

MONTH	NUMBER OF ORDERS Out of stock	Total	% ORDERS OUT OF STOCK	No. ITEMS NOT SUPPLIED EX-STOCK	No. OF DELIVERIES	% ITEM NOT SUPPLIED
OCT.84	9	56	16	36	156	23
NOV.84	6	33	18	26	108	24
DEC.84	1	16	9	7	48	26
JAN.85	5	32	16	26	117	22
FEB.85	7	44	16	74	209	35
MAR.85	11	42	26	112	218	51
APR.85	12	43	28	58	175	33
MAY 85	18	54	33	138	239	58
JUN.85	12	43	28	63	139	45
JUL.85	13	43	30	64	120	53
AUG.85	19	50	38	151	243	62
SEP.85	31	83	37	258	385	67

Summary of key results

Total orders = 543
Number supplied ex-stock = 399
Number not supplied ex-stock = 144

Note 1. A total of 728 deliveries was made to fill 543 orders, giving an excess deliveries rate of 34%.

Note 2. The largest selling range had a worse delivery performance than the other items in the company's range, with 27.2% of orders being part delivered. This compares with 23.6% of the other product lines.

Note 3. The average size of order delivered complete contained 2.9 items. The average size of order not delivered complete contained 7 items.

Table 29 Size of Orders and Delivery Performance

ORDER SIZE	NO. OF ORDERS	NUMBER DELIVERED Ex-stock	Not ex-stock	No. OF LARGEST RANGE NOT DELIVERED EX-STOCK
1	244	229	15	5
2	58	46	12	8
3	29	21	8	7
4	38	25	13	8
5	25	14	11	9
6	19	7	12	7
7	26	9	17	12
8	24	10	14	8
9	17	9	8	4
10	7	5	2	1
11 +	56	23	33	15

The above reports provide important information about delivery. While the ultimate objective is delivery to the customers, it is also necessary to monitor the steps leading to this final stage. A way of achieving this aim, which also reveals the degree of uncertainty within the production system, is shown below.

B.22 Measuring Internal Delivery Reliability

A number of the cases demonstrated high levels of internal inconsistency in delivering production between sequential operations. This was reflected eventually in late deliveries to customers, although, as discussed above, this was not effectively measured. It was also reflected in the level of WIP, which was only measured in aggregate terms. This made it difficult to gauge the effect on the smooth running of production.

I showed above that output in the brakes case was particularly prone to erratic variations, associated with month end storming of output targets. This inconsistency was partly shown by the report which showed the percentage of the monthly schedule achieved each week. This measure, however, was too limited and not sufficiently focused on showing management the level of inconsistency. The CLIP scoring system developed by Mullard would have been of value in this context. The initial parameters of good delivery could have been set widely and subsequently narrowed both in their tolerances and frequency.

Figure 22 The CLIP System Applied to the Production
(Data taken from brake case for 4 weekly periods)

PRODUCTS	DATES					
	Wks 45/8 OT. Sc.	Wks 49/52 OT. Sc.	Wks 1/4 OT. Sc.	Wks 5/8 OT.Sc.	Wks 9/12 OT. Sc.	Wks 13/17 OT. Sc.
A	90% 0	83% 0	62% 0	84% 0	88% 0	81% 0
B	90% 0	83% 0	64% 0	97% 1	96% 1	83% 0
C	92% 0	90% 0	76% 0	86% 0	87% 0	101% 1
D	61% 0	77% 0	33% 0	95% 1	75% 0	63% 0
E	84% 0	22% 0	115% 0	60% 0	60% 0	92% 0
Total CLIP	0	0	0	40%	20%	20%

CODE OT. = Output as percentage of schedule.
Sc. = Clip score, either 0, if outside schedule limit or 1, if inside limits.

Interpreting the above data, we can see that only in weeks 5 to 8 were any of the products within the range -5% to +10% of the planned production rate. Thus, given the general pattern of shortfalls with occasional excesses, it was unlikely that the production schedule would be achieved. If CLIP scores were used between all key departments the inter-departmental delivery performance could have been monitored and stimulated efforts to improve. When performance was sufficiently high, the interval between reviews could have been reduced to weekly and possibly eventually to daily. Under this system the major part of the level of variability and thus uncertainty would have been reduced and so they could have improved cost performance by dismantling the costly buffer stocks between processes. Both sections B.21 and B.22 have thus shown that simple inexpensive measures are available to monitor delivery performance. Further sophistication is also often easily available, but the critical issue appears to be the recognition of the necessity to monitor at all.

B.3 MONITORING QUALITY

The Profit Impact of Market Strategy (PIMS) study showed that above average quality is important for increased market share. Recent production management literature, Price (1984), Crosby (1979) has shown that high quality can lead to lower costs of manufacture. Additionally, as discussed above, good quality in internal activities reduces the uncertainty within plants and thus increases the scope for improved control. To attain these benefits, changes in information are necessary. Thus, for many reasons, quality needs to be recognized as a strategic issue and not simply a matter of cost saving. At the managing director level two issues are central; the quality received by customers and the total cost of achieving quality as a proportion of sales turnover. Both issues need to be monitored to show their changes over time and if possible, at appropriate intervals, to compare them with competitors. I assume in the reports below that the aim is zero defects sent to the customer and the lowest total cost system of meeting that aim.

B.31 Measuring the Cost of Quality

Improved quality was widely identified as an OWC; yet, although in most cases dispatched quality was measured, neither it, nor more strategic information, was regularly sent to senior management. In addition other important tactical issues, such as the level of internal scrap / rejects, were not reported to senior management. The effect of these omissions was that performance on quality was not systematically reviewed and improvement plans were not implemented in line with the OWC. One of the central reasons for the underemphasis on quality at senior management level was the systematic understating of its costs. The few reports available only considered some of the costs of failure, not their full costs, nor indeed the costs of prevention and appraisal. It has been estimated by quality professionals that the total cost of quality, (i.e. not satisfying the customer first time), is in the order of 20% of sales turnover. Crosby claims to have reduced ITT's cost of quality to 5% of sales, by careful control and improvement.

The Managing Directors in the pump and clutch cases received good warranty claims analysis information, while the kitchen furniture case Managing Director had recently started to receive data on customer complaints. However, such information falls short of that needed to help senior management make the necessary strategic decisions to position their companies in terms of quality and its costs. In most of the case studies the data needed to produce these reports was available, but was dispersed into various sub-systems. With the type of data shown in Figure 23, a Manufacturing Director could monitor his plant's improvement programmes to ensure that they made adequate progress on the critical issues.

Figure 23 The Cost of Quality

Cost of salaries of quality control and inspection	xxx
Indirect costs (National Insurance etc.)	xxx
Cost of space	xxx
Cost of inspection equipment P.A.	xxx
Cost of rejects	xxx
Cost of re-worked products	xxx
Cost of warranty claims	xxx
Cost of items delayed waiting inspection	xxx
Cost of changes to correct errors (engineering changes, tools changes, software corrections)	xxx
Any other costs of errors	xxx
Cost of customer dissatisfaction	xxx
Total cost of Quality	x,xxx

Neither trends nor the inter-firm comparisons need frequent monitoring when they are working well. Under such conditions three monthly intervals will be sufficient, but when a firm is seeking rapid changes in its performance much more frequent monitoring is required to check progress and to ensure that appropriate pressures are sustained. When longer time periods occur between monitoring it is essential that small changes in trends are rapidly identified. This can be accomplished by adopting a modified version of the CUSUM programme which tracks progress in controlling against a specified target level of improvements.

As well as monitoring the cost and level of quality reaching the customers, it is also desirable to monitor the uncertainty within production which arises from variation of production and purchased quality.

B.32 Measuring Internal Quality Levels

I showed above that quality to customers and internal rejection rates were not reported to senior managers. I also showed that the rejection rate in some processes was variable. In the brake and ceramics cases this variability caused delays and / or over-production to compensate for the expected levels of rejection. I showed in the brake case that even this correction factor was significantly incorrect, at 2% compared with an actual 7%.

Were the cases to improve their control in this aspect of performance, it would be likely that they would adopt a programme of error prevention, such as TQC, rather than the more limited Statistical Process Control (SPC) approach adopted in some cases.

Figure 24 Summary of Internal Quality Data Affecting Uncertainty
(Data taken from brake case)

Percentage of rejects WIP	Percentage of setups failing	Percentage of final assemblies first offs rejected
7	24	0.19 to 35

The above data could be recorded by department and trends monitored. In addition data on the level of customer returns and the total cost of administering the quality control system, plus the value of rejects and reworks, could be calculated and shown as a percentage of sales turnover.

In the brake case, where the ratio of inspectors to production directs was well known, and at 25% compared with a target of 17%, the trend was not reviewed, either as a proportion of costs or turnover. The brake case showed other data which provided important information at supervisory level. In addition to the rejection of components, there was considerable rejection by inspection of the 'first-offs' offered to them and a stopping of the process because it was outside the SPC control limits. The data dealing with the above issues for a period is shown below as Figure 25.

Figure 25 Rejection of 'First-offs' and 'Process Stops'
by Patrol Inspection (from brake case)

TYPE OF MACHINE	No. of 1st offs	Number failing	Percentage failure	No.of patrol visits	No.of process stops
Wickman	12	6	50	N/A	N/A
Gnutti	18	1	31	107	17
LSA	9	2	22	210	63
Schutti	6	3	50	N/A	N/A
Wavis	20	3	15	31	7
Millwalkee	5	1	20	113	3
Plunge Grinder	1	0	-	76	36
Deidesheim	11	7	73	307	197

The data shows that some processes were not being set up correctly first time and that some processes were frequently found to be outside the SPC control limits. By monitoring such data it is reasonable to expect it to stimulate action to improve these sources of uncertainty, affecting both quality and the time required to produce the output.

B.4 THE NEED TO MEASURE FLEXIBILITY & COMPLEXITY

I have shown that the complexity of the manufacturing task results from decisions about the product range, processes and systems. Production needs to be able to match the level of flexibility to the complexity of the manufacturing task. Flexibility is essentially the ability to economically and effectively adjust output levels, products made and / or introduce new products, in line with the demands of the market rather than of the manufacturing system. Many manufacturing systems can be adjusted, but at unacceptable costs in terms of reduced capacity or costs of production. The development of JIT and TQC systems has enabled a number of firms to reduce the costs of flexibility to acceptable levels. However, because the aim of flexibility has received limited attention, Shingo (1981), Schonberger (1982) and Slack (1983), few means of measuring flexibility exist.

The turbulent market faced by many manufacturers gives rise to the complexity which in turn requires them to achieve high flexibility. Yet, as I have shown, the traditional paradigm of control neither measures it nor encourages its development. It is therefore important that the internal measures of the revised paradigm monitor progress in increasing this characteristic, so that there is a reduced conflict between what is required in the market and achievable by production. Three forms of flexibility tend to attract attention; the ability to smoothly introduce new products, to change designs / modify existing designs and finally to increase / decrease volumes. The critical skill is to make these changes without disruption to the operation of production. It can be argued that

by measuring flexibility we have, in effect, measured the competence of workers and the system to perform effective changes.

B.41 Means of Measuring Flexibility

Reduced lead time and greater flexibility were only recognized by senior management in one case (ceramics) as a critical element in competitiveness. Similarly, in only one other case (medical products) was the lead time of product introduction recognized and, in this instance, measured. In none of the cases were the production lead times measured, although several used stock turn figures which gave limited guidance to lead times and some indication of flexibility.

I showed that senior management in the pump and clutch cases developed simple measures showing the variety per month on their plants. While their purpose was used to reduce variety, it indirectly demonstrated means of looking at the plant's flexibility.

Because of the two phase nature of the approach to complexity, (initial reduction until a state of control is achieved and gradual increase to achieve advantageous but complex tasks when uncertainty and competence are growing), the measures used must be capable of accommodating the different characteristics involved. Thus in the clutch case, where variety had contributed to the loss of control in production, the product expansion programme should have been limited until progress on improving the manufacturing system had been accomplished. Yet in the pump case where the level of control was much higher, the product range expansion should have proceeded in line with increased efforts on reduced uncertainty and increased competence of production management and its work force.

One means of measuring overall flexibility is to compare the market's requirements in a period with production's output. Such a measure need only be used at say annual intervals to check the long term progress towards greater flexibility. Figure 26 below demonstrates a measure which matches both the variety of types produced and the output quantities. These are turned into scores which are multiplied to give an index of flexibility.

Figure 26 A Corporate Measure of Flexibility

Product Identity	Pattern of Demand	Pattern of Production
P110		
P121	100	850
	175	-
P125	503	-
P129	1005	4500
P256	6	-
P345	791	-
P347	899	-
P367	561	-
P439	211	-
P641	317	1000
TOTAL	4568	6350

(Illustrative data only)

Figure 26 shows that only three out of ten products were produced in the period and considerable over production occurred on these lines. The three lines produced totalled 6350 against their demand of 1422. This gave an index 1422/6350 = 0.224, when multiplied by the index (0.3) of lines produced against lines sold, with the resulting score being 0.067. This could be called a flexibility score of 6.7%. Clearly it does not reflect the cost of flexibility which must be set against the score.

B.42 Improved Flexibility with Quick Changeovers

One way of reducing the cost of flexibility is to quickly changeover between products. The two automotive replacement part cases were particular examples where the product range had to be wide and response times fast. Yet with strong

price competition both needed to achieve these wide ranges and good deliveries with the minimum of inventories. The ability to achieve this combination of aims was dependent on improving the setup times so that they were substantially reduced. The following Figure demonstrates the type of information that was needed to review the rate of progress on setup time reductions.

Figure 27 Monitoring Improvements in Changeover Times

IMPROVEMENTS	OVER	OVER
No. of Improvements in set up times	75%	90%
January to March		
April to June	10	5
July to September	17	9
October to December	9	15

(Illustrative data only)

Figure 27 demonstrates the type of report which could be used to show how many setups had been improved in a period. It shows how many of the improvements had reduced setup times by 75% and 90%. As I showed above in Figure 25, in the brake case the level of setups rejected by first-off inspectors demonstrated one cause of the long time taken in changing over from one product to another. This information would need to be considered along with the more obvious measures of flexibility, if the management were to seek improved control and performance.

B.3 MEASURING STRATEGIC COSTS

I showed that senior management in all seven cases was provided with comprehensive cost data. Such data, despite its importance, has been considered to be outside the scope of this thesis. However, one important aspect of strategic cost data has shown itself necessary for inclusion. This is the use of overhead rates and their application to production cost performance. In the pump case one of the major product groups was considered very uncompetitive. An internal re-allocation of overheads, with no physical change in the system, led to a

reduction from 1100% to 650%. The product group was then considered to be the second cheapest in the market place! My study showed overheads were particularly affected by two elements in the manufacturing system: the number of clerical transactions and the level of inventory. In none of the cases were these costs directly related to the specific product groups and their processes. Rather they were averaged plant wide and allocated on the basis of direct labour hours. Although changes to more flow like processes would have reduced these costs significantly, there were no attempts either to make such changes or to reflect the overheads appropriately, when they existed in the plant. To some extent the same applied to the difference between large and small batches where the number of transactions were the same regardless of batch size, but the proportion of costs incurred was different. Similarly, the batch sizes for items with low demand levels were proportionally much larger than for items with large demand levels. Yet these additional costs were never reflected in strategic decisions about product range.

8.6 MEASURES REFLECTING REDUCTIONS IN UNCERTAINTY

As demonstrated above the traditional approach to controlling production normally accepts a high degree of uncertainty within manufacturing. This uncertainty occurs in the delivery of materials to the plant, the internal flow rates between work stations, variable quality, inconsistent machine availabilities and worker attendance patterns. These and other uncertainties make economic control difficult because the low level of predictability involved makes it necessary to protect the system with various forms of buffer. Yet these buffers have become so common in the traditionally controlled plant that they are rarely challenged. They have become accepted as part of the normal life of production. This acceptance has meant that they are not given much priority in terms of monitoring, particularly as managers do not expect them to change or be particularly changeable.

B.7 REDUCED UNCERTAINTY IN MACHINE / PLANT AVAILABILITY

The impact of plant maintenance on product quality and delivery reliability has been known for many years. Generally, attention to maintenance has been when either quality falls below a nominal level or capacity is reduced. As such, the few measures that are made are essentially tactical in nature. However, renewed attention has been given to maintenance in recent years as leading producers have sought to achieve dramatic improvements in quality and lead times. These goals, unlike the previous goals, are strategic. They are required to be supported by monitoring systems which reveal the impact of any lost production time or reduction in performance. Such controls must be capable of analysis, so that revised practices of maintenance can be developed as necessary.

B.8 ENSURING THAT THE MEASURES OF PERFORMANCE ARE USED TO ACHIEVE CONTROL AND IMPROVEMENT

I noted above that it was essential that the development of more sophisticated measures of performance does not lead to subtle forms of mis-direction. Neither must the cost of developing such measures be allowed to consume the savings produced by the information provided.

The revised paradigm has been premised on the view that production performance has, in many companies, a significant impact on corporate competitiveness. Therefore, the control system strategy must directly and economically reflect the ways in which production needs to support competitiveness. Given that the OQC / OWC or the KMTs have been correctly established, it is then necessary to link the control reports to them. While this ensures that the direction is correct, it does not deal with the often under emphasised issue of the rate of improvement that needs to be achieved in order to be competitive. It is therefore necessary for management to monitor progress to identify whether sufficient improvements are being accomplished.

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