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LINKING PERFORMANCE REQUIREMENTS WITH PROCESS IMPROVEMENT ACTIONS FOR BUSINESS PROCESS RE-DESIGN

by

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Linking Performance Requirements with Process Improvement Actions for Business Process Re-design

Cita Lorraine Wood

Abstract

This thesis presents research that extends current knowledge in the area of business process re-design, with a specific focus on the 'Make Product' process within manufacturing organisations.

Current business process re-design approaches offer only limited guidance on the specific changes that can be made to a process when re-designing it to achieve the desired performance improvements and often overlook any strategically derived performance requirements when re-designing the process. Case experience suggests that practitioners do not consider the performance requirements of their business processes when re-designing them and that the actions they take to achieve performance improvements are not selected with regard to any strategically derived performance requirements.

This exploratory research investigates whether relationships can be established between the changes that can be made to a process when re-designing it and the performance improvements gained by implementing those changes. It then questions whether those relationships can be used to help companies to select the appropriate process changes to implement in order to meet their specific performance requirements.

Performance Requirements and process changes (Process Improvement Actions) were derived from the relevant literature and included in a questionnaire designed to ascertain the strength of relationships between them. The questionnaire was subject to preliminary and pilot testing to improve validation and reliability prior to being administered to international business process re-design 'experts'.

Statistical analysis of the questionnaire data resulted in a ranked list of Process Improvement Actions for each of the Performance Requirements. These were presented in a format for inclusion in a process-based change handbook and enable the practitioner to set the agenda for the intervention and select the Process Improvement Actions on the basis of the Performance Requirements. The Performance Requirements should be derived from the strategy of the company or change programme so a strategic focus is maintained throughout re-design.

It was also found that of the thirteen Process Improvement Actions included in the questionnaire just five are needed to achieve improvements in a majority (80%) of the performance requirements.

This research showed that it is possible to establish links between Performance Requirements and Process Improvement Actions and according to successful validation by practitioners, against an accepted model, that these can be used for business process re-design, laying foundations for future research in the area.

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To my friends, colleagues and fellow PhD students with whom I have shared so much over the last few years I offer apologies for my whinging and thanks for listening. Particular mention should be given to Jo and Mel who have provided many an entertaining diversion during the past few years and to Dave M for his much-treasured friendship.

And last but by no means least I thank my family; I couldn't wish for a better one!

Author's Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award.

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Although the author has worked as part of a research team and as a BAE Systems employee during this research project the research and the contribution made as described in this thesis were the results of work undertaken solely by the author.

Relevant seminars and conferences were attended. These included:

- Knowledge Creation Workshop, Liverpool John Moore University, July 1998

- 'Strategic Management of the Manufacturing Value Chain', Proceedings of the International Conference of the Manufacturing Value-Chain, IFIP, Troon, Scotland, August 1998

- Engineering and Physical Sciences Research Council Research Methods Workshop, University of Cambridge, 1999

- European Institute for Advanced Studies in Management, EDEN Doctoral Seminar on Research Methodology in Operations Management, Brussels, February 1999

- 'Performance Measurement – Past, Present and Future' Second International Conference on Performance Measurement, University of Cambridge, July 2000

The following publications were produced from this research:

- C Wood, S Childe, 2000, 'The Use of Performance Measures in the Redesign of Business Processes, *'Performance Measurement – Past, Present and* Future' Second International Conference on Performance Measurement, University of Cambridge, UK

- C Wood, S Childe, 1998 'Process re-engineering – Commitment, Consultants and all that Stuff!' *'Strategic Management of the Manufacturing Value Chain'*, Proceedings of the International Conference of the Manufacturing Value-Chain, IFIP, Troon, Scotland

- Childe S J, Maull R S, Smart P A, Rogers T J, Greswell T J, Wood C L, Radnor Z, 2000, *A Handbook of Process Based Change*, Manufacturing and Business Systems Group, University of Plymouth, UK

- Smart P A, Maull R S, Bennett J P, Childe S J, Greswell T, Wood C, Rogers T, 1999 'Characterising Process-Based Change in SMEs*: An Empirical Approach, 'Managing Operations Networks'*, Proceedings of the 6th European Operations Management Conference, Venice Italy

Signed... *C L Wood* ....

Date... *25TH APRIL 2002*

Chapter 1 - Introduction

This thesis presents the work conducted during a research project which aimed to extend knowledge in the area of business process re-design, with a specific focus on the 'Make Product' process within manufacturing organisations.

This chapter begins by presenting the background to the research and justifying why business process re-design was selected as the research area. It goes on to outline the 'gap' that was addressed by the research in terms of the research aim and research questions. This is followed by a summary of the contribution of the research to existing knowledge. Finally an overall description of the research and thesis is presented through a chapter by chapter summary.

1.1 Background to the research

According to Elzinga et al (1999) *'Nearly all enterprises are engaged in assessing ways in which their productivity, product quality and operations can be improved.'* The performance improvements required are achieved through the improvement, simplification, re-design or re-engineering of business processes. These approaches, collectively referred to as Business Process Engineering by Elzinga at al (1999) are, they believe *'...an important ingredient of successful enterprises in the private and public sectors.'*

In a cross industry survey of just over six hundred managers published by the Institute of Management (Charlesworth, 2000) *'Nearly seven in ten firms have already introduced a formal improvement programme, and one in fourteen have plans for such a programme.'*

It would appear therefore that the use of improvement initiatives and the re-design of business processes to achieve business results are as popular today as they were when

Michael Hammer first introduced the concept of Business Process Re-engineering to the business world in 1990. Hammer and Champy (1993), described it as '*...the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed.*'

Business process re-engineering, process simplification, and process improvement all require the re-design of business processes, that is the configuration or reconfiguration of a business process to improve process performance and ultimately business results. It is important therefore that companies should be competent at re-designing processes and that the processes they design should be capable of meeting the performance standards set for them. The success or failure of a re-designed process in meeting its performance targets will not only reflect on the business results, but will set a precedent for future improvement initiatives within the company. Success of the re-designed process is therefore extremely important.

Prior to undertaking the work presented in this thesis the researcher was employed as a Manufacturing Engineer within a large manufacturing company. Observations of business process re-design activities whilst performing that role led the researcher to believe that business process re-design activities within companies could be improved through further guidance in determining the changes to make. It also appeared that even though process re-design projects often had lofty goals for improvement, the performance of the process was not measured or even considered when re-designing. The researcher visited the company regularly throughout her research always finding some process re-design or improvement underway. On returning to the company permanently some three years later she found them in the midst of another major re-engineering project. It would seem that some form of business process re-engineering, re-design or improvement had been underway in that company for at least the last four years.

So far as research is concerned there are still many papers on various aspects of business process re-design, process-based change and continuous improvement being published in journals within the area of Production and Operations Management. The number of case studies included in these papers regarding business process re-design, re-engineering and continuous improvement would indicate that the company described is not alone in striving for the process improvements on offer.

Business process re-engineering, business process re-design and continuous improvement are still very much on the agenda of both researchers and companies.

1.2 Research aim

The aim of this research is to add to existing knowledge regarding the re-design of business processes within manufacturing companies. The results of the research should offer guidance in selecting the changes to make to a process when re-designing it (Process Improvement Actions), whilst maintaining a focus on strategically derived performance requirements. The research will do this by investigating whether relationships can be established between the changes that can be made to a process and the performance improvements gained by implementing those changes. If such relationships can be established it will question whether those relationships can be used to help companies to select the appropriate process changes to implement to meet specific performance requirements. Strategically derived performance requirements will be used to drive the selection of process changes.

1.3 Research questions

In order to focus the research three key research questions were formulated:

1. *Is it possible to identify and characterise a set of generic Process Improvement Actions?*
2. *Can individual improvement actions be linked to specific performance improvements and what are those relationships?*
3. *If such links can be established is it possible to use them to direct appropriate actions in process re-design, to achieve the performance targets set for the process?*

In order to answer the main questions above the following sub-questions must be addressed:

- *What are the possible Process Improvement Actions?*
- *What are the possible performance improvements?*
- *What is the role of performance measurement within process re-design?*
- *What performance improvements can be gained from each of the Process Improvement Actions?*

1.4 Contribution to knowledge

There is a proliferation of research and literature regarding process-based change and business process re-engineering, yet much of it skims over the actual re-design of the business process. The reconfiguration of a process from the 'as-is' to the 'to-be' state is a major stage within business process re-engineering and is the area to which this research contributes knowledge. The main areas of contribution are discussed in full in Chapter 11.

In summary this research:

- *Shows that links can be established between Performance Requirements and Process Improvement Actions and that those links can be used in re-design*
- *Produced a ranked list of Process Improvement Actions that should be considered for each specific Performance Requirement, allowing the practitioner to set the agenda for intervention*
- *Produced a set of generic Process Improvement Actions and a list of Performance Requirements applicable to the 'Make Product' process*

- *Proposes a business process re-design approach that ensures a focus on strategy and encourages the use of strategic Performance Requirements throughout re-design*
- *Presents Practitioner Matrices that give structure to business process re-design and can be used to trigger re-design ideas*
- *Identified five key Process Improvement Actions for achieving process improvements.*

1.5 Structure of the thesis

This thesis consists of eleven chapters. This section gives a brief overview of each chapter.

Chapter 1

This chapter introduces the research. It outlines the background and aims of the research, presents the research questions addressed and the knowledge that the research contributes to existing theory.

Chapter 2

Chapter 2 outlines the aims of the research, the exploratory nature of the study, the formulation of the research questions and the scope of the research. The research process that was followed, which consisted of eight stages is described in terms of the main activities undertaken, the decisions made by the researcher and the specific philosophical stance and research method adopted.

Chapter 3

Chapter 3 outlines the literature review conducted to investigate the various approaches for business process re-design available and the role that performance measurement plays in them. This review led to the identification of weaknesses in current business process re-design approaches, both radical and incremental, and of instances where performance measurement could be used to support re-design activities. To complete the picture regarding process re-design approaches and the role of performance measurement empirical research was also conducted in the form of case studies.

Chapter 4

Chapter 4 outlines the literature review conducted to identify any aspects of performance measurement that may support business process re-design activities. This review led to the identification of several key characteristics of a performance measurement system. It goes on to consider the applicability of these characteristics to business process re-design.

Chapter 5

Chapter 5 describes the derivation of the Process Improvement Actions, those changes that can be applied to a process in order to improve it. A generic list and associated definitions were derived from the many suggested throughout process re-design and re-engineering literature, in which they are referred to as tools, guidelines etc. The establishment of links between these Process Improvement Actions and the Performance Requirements derived in Chapter 6 is key to this research project.

Chapter 6

Chapter 6 describes the selection of the performance dimensions and requirements used within this research. A set of characteristics for assessing the applicability of performance dimensions and requirements to this research was developed and stated. Performance dimensions and requirements that satisfied these applicability characteristics were then selected from those suggested throughout performance measurement literature.

Chapter 7

Chapter 7 takes the Process Improvement Actions and Performance Requirements from Chapters 5 and 6 and uses them as variables within a questionnaire. The aim of this questionnaire was to establish links between the Performance Requirements and the

Process Improvement Actions and to ascertain the strength of those links. The design of the questionnaire is discussed including the preliminary and pilot testing necessary to ensure the validity and reliability of the questionnaire.

The sample of process re-design experts to whom the final questionnaire was administered is discussed in terms of the sampling method, survey size, pureness and possible bias.

Chapter 8

Chapter 8 discusses the analysis and initial findings of the completed questionnaires. The data from the questionnaire was analysed using descriptive statistics, which gave an overall picture of the data. The results of this analysis are presented showing the 'strong' Process Improvement Action to Performance Requirement links and discussing the patterns that emerged.

The chapter then describes an inferential statistical test used to draw conclusions from the data regarding the ranking of Process Improvement Actions and the statistical strength of those rankings; the Wilcoxon Matched Pairs Test.

Chapter 9

Chapter 9 presents the findings of the statistical analysis. The results of the Wilcoxon Matched Pairs Test are used to rank Process Improvement Actions according to the strength of each one's effect on specific Performance Requirements. These rankings enable the links established between Performance Requirements and Process Improvement Actions to be presented in priority order of implementation. The results of individual questions, the popularity of Process Improvement Actions and trends that emerged are discussed.

Chapter 10

The first part of Chapter 10 describes how the results of the statistical analysis presented in Chapter 9 were incorporated into Practitioner Matrices and a business process re-design approach suitable for practitioners. Written in the format of pages for a process-based change handbook this includes the Practitioner Matrices containing the links between Performance Requirements and Process Improvement Actions, instructions for their use and supporting information regarding process thinking and the importance of having strategically derived performance requirements.

The second part of the chapter discusses the validation of the business process re-design approach with practitioners. It describes the use of a feedback questionnaire to validate the concept of using the links within a business process re-design approach, and the business process re-design approach and matrices, in terms of their content and their relevance to the practitioner. Finally the results of the validation questionnaire are presented and discussed.

Chapter 11

Chapter 11 brings the research to a close. It presents the overall conclusions and findings and details the contribution to knowledge. The thesis concludes with a critical review of the research and a discussion of possible areas for future research.

1.6 Conclusion

This chapter has outlined the background to the research undertaken and documented in this thesis. The particular area and problem on which the research is focused was introduced through the presentation of the research aims and of the research questions posed. The success of the research in achieving the research aims and answering the research questions is shown through the contribution to knowledge stated. Finally a chapter by chapter summary provides an overall account of the research.

The remainder of the thesis describes the research undertaken from the initial literature reviews to the final conclusions reached.

Chapter 2 - Research process and methods

This chapter describes the overall research process and methods used in this research. The aims of the research are introduced and the exploratory nature of the study discussed. The alternative philosophical stances available to the researcher are then outlined and the position of the researcher stated. The research process followed is explained highlighting the eight main activities undertaken, the decisions made by the researcher and the reasons for adopting specific philosophical stances and research methods discussed.

2.1 Aims of the research

The aim of this research was to investigate and if possible establish the relationships between the possible changes that can be made to a process (Process Improvement Actions) and the performance improvements gained from their implementation. Those undertaking a business process re-design project could then use these relationships in selecting the appropriate Process Improvement Action to meet the performance requirements of the process. This would offer new knowledge in the area of business process re-design and could be incorporated into a business process re-design approach that would overcome some of the weaknesses of current re-design approaches identified in Chapter 3.

2.2 Nature of the study

The research constitutes an initial study into the feasibility of establishing and using links between Process Improvement Actions and Performance Requirements in a business process re-design approach.

Due to the exploratory nature of the research and its position within the domain of

Production and Operations Management, not pure science, the links established and presented ultimately in the Practitioner Matrices are suggestions based on the opinion of experts, they are not hard facts derived from experiments.

2.3 Alternative philosophical stances

It is important in any research project to acknowledge the philosophical stance that has been adopted in undertaking the research. The information and findings of the research can then be understood within the context of the philosophical stance.

Many different authors discuss research philosophy and offer frameworks outlining the possible stances that can be taken. The framework adopted for use within this research is that of Meredith et al (1989), shown in Figure 2.1. This was the framework that the researcher preferred, finding the structure and way in which the alternative paradigms were explained clear and understandable. The diagram of the framework itself provides much information regarding the alternative paradigms in an efficient and clear way. The key reason for selecting Meredith et al (1989) was however the fact that it was developed specifically for research in Operations Management, the same research domain as this study, making it easier to apply in the context of the research.

The main alternative to Meredith et al (1989) was that of Creswell (1994) who presents two research paradigms, qualitative and quantitative. These paradigms and their associated ontological, epistemological, axiological, rhetorical and methodological assumptions are presented as two extremes. The researcher found this limiting, often considering her position to be somewhere between the two.

The Meredith et al (1989) framework shown in Figure 2.1 clearly shows these intermediate positions, as well as the extremes.

In addition, the researcher, whose background is in Manufacturing Engineering, found the rhetoric and language used by Meredith et al (1989) preferable to that of Creswell who wrote primarily for the human and social sciences.

The Meredith et al (1989) framework presents the alternative research paradigms available and can be used by the researcher to show clearly her position with regard to the research paradigm adopted. It has two dimensions, rational/existential and natural/artificial as shown in Figure 2.1.

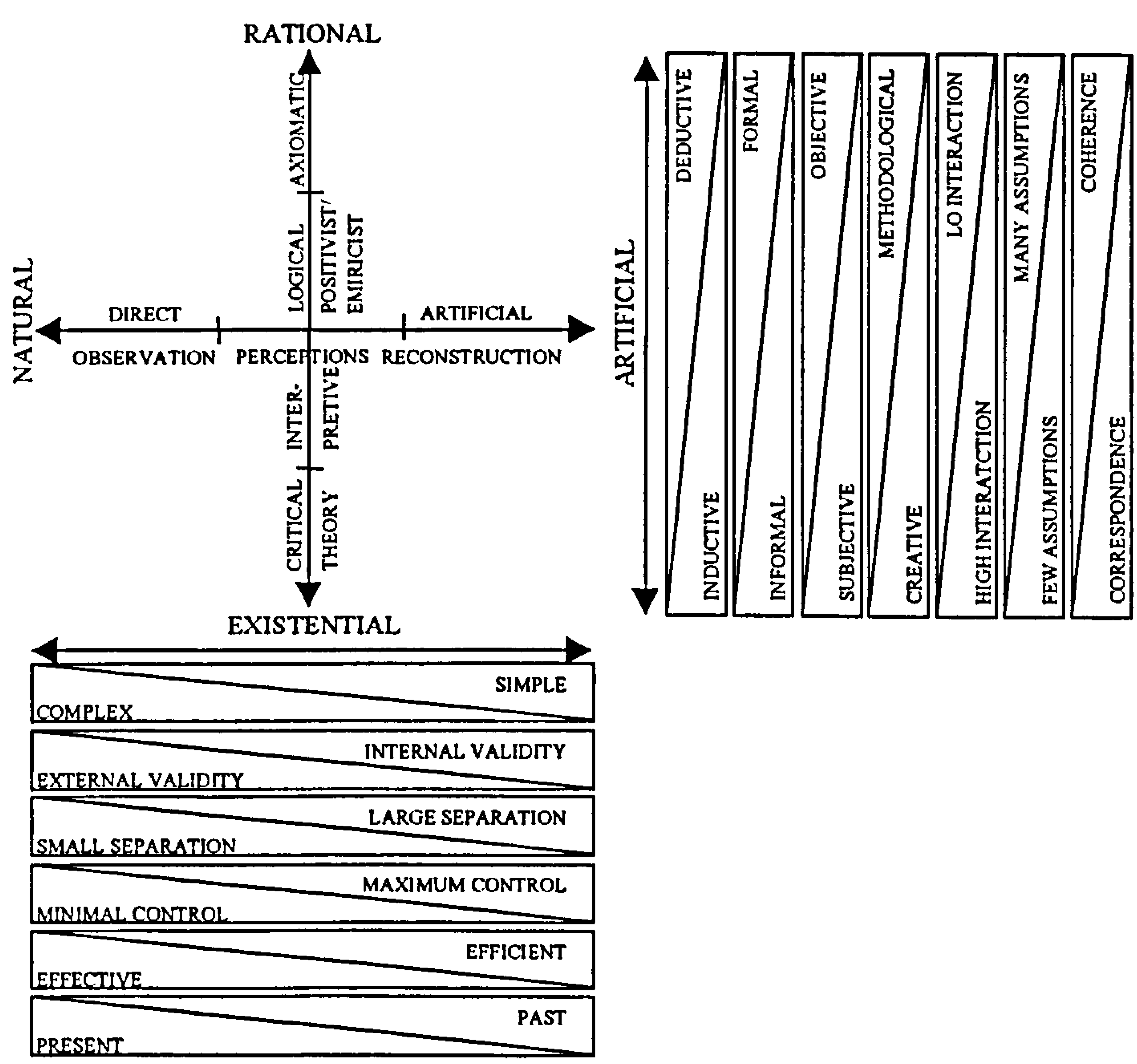


Figure 2.1 - A generic research framework (Meredith et al, 1989)

2.3.1 The rational/existential dimension

This relates to the epistemological characteristics of the research process. It concerns the relationship of the researcher to what is being researched (Creswell, 1994). Meredith et al (1989) refer to it as '.... *the philosophical approach to generating knowledge;.......the viewpoint of the researcher.'*

At one end of the extreme is the rational stance where structure and logic are seen as a measure of the truth. At the other end is the existential stance in which knowledge is acquired by people's interaction with the environment. Meredith et al (1989) identified four possible perspectives on the rational/existential dimension: axiomatic, logical positivist/empiricist, interpretive and critical theory (see Figure 2.1).

Axiomatic

The axiomatic perspective is placed at the rational end of the continuum. It is characterised by research methods that have formal procedures, the high degree of assumptions made regarding the organisation under study, the consistency of goals and the embracing of scientific management principles.

Logical positivist / empiricist

The logical positivist perspective is next on the continuum. It is characterised by the assumption that the problem being studied can be isolated from the real world, the context in which it occurs.

Interpretive

The interpretive perspective includes the context of what is being researched as part of the study. It tends to concentrate on the study of people and of the way in which they understand and conceptualise what is going on around them.

Critical theory

Critical theory aims to take the positivist and interpretive perspectives and considers both the way that people behave and the way that they understand that behaviour.

2.3.2 The natural/artificial dimension

The natural/artificial dimension relates to the nature of information used and from where that information is collected.

At the natural end of the extreme is empiricism, the derivation of explanations from real concrete data in an objective way. At the artificial end is subjectivism, the derivation of explanation from an artificial reconstruction of the real world. The three possible perspectives suggested by Meredith et al (1989) on the natural/artificial dimension are direct observation, perceptions and artificial reconstruction (see Figure 2.1).

Direct observation of object reality

This refers to the direct observation of the problem by the researcher. It assumes that there is object reality and that humans can sense it. Observations can be made using an axiomatic, positivist, interpretive or critical theory perspective.

Perceptions of object reality

This refers to the observation of a problem through the eyes of others. It is interested in peoples' perceptions. Observations can be made using an axiomatic, positivist, interpretive or critical theory perspective.

Artificial reconstruction of object reality

This refers to the practice of taking observations, both directly or as perceptions and reconstructing them in another form more suitable for the research, such as an experiment.

2.4 Alternative research methods

To complement the research paradigm framework Meredith et al (1989) also present a framework for research methods. This is shown in Figure 2.2. Once the researcher has placed her research on the rational/existential and natural/artificial axis of the research paradigm framework she can use the research method framework to identify research methods appropriate to that philosophical stance.

RATIONAL ↑ … ↓ EXISTENTIAL / NATURAL ← … → ARTIFICIAL	DIRECT OBSERVATION OF OBJECT REALITY	PEOPLE'S PERCEPTIONS OF OBJECT REALITY	ARTIFICIAL RECONSTRUCTION OF OBJECT REALITY
AXIOMATIC			• REASON/LOGIC/ THEOREMS • NORMATIVE MODELLING • DESCRIPTIVE MODELLING
LOGICAL POSITIVIST/ EMPIRICIST	• FIELD STUDIES • FIELD EXPERIMENTS	• STRUCTURED INTERVIEWING • SURVEY RESEARCH	• PROTOTYPING • PHYSICAL MODELLING • LABORATORY EXPERIMENTATION • SIMULATION
INTERPRETIVE	• ACTION RESEARCH • CASE STUDIES	• HISTORICAL ANALYSIS • DELPHI • INTENSIVE INTERVIEWING • EXPERT PANELS • FUTURES/SCENARIOS	• CONCEPTUAL MODELLING • HERMENEUTICS
CRITICAL THEORY		• INTROSPECTIVE REFLECTION	

Figure 2.2 - A framework for research methods (Meredith et al, 1989)

2.5 The philosophical stance of the researcher

The researcher adopted different philosophical stances for different parts of the research. One stance was adopted for the empirical research undertaken to formulate the research questions and another for the research undertaken to answer these questions.

- Formulating the research questions

In order to formulate the research questions the researcher wanted to investigate current approaches to business process re-design in practice, as well as within theory. To understand the current situation regarding business process re-design within companies the researcher wished to observe 'real' business process re-design projects. Primarily the researcher wanted to make direct observations of such projects and interpret those observations in the context of the research. Her position on the generic research framework offered by Meredith et al (1989) is indicated in Figure 2.3. The research method used was case study research. A full discussion regarding the reasons for adopting this philosophical stance and research method is presented in section 2.6.2.2.1.

- Answering the research questions

To answer the research questions the researcher wished to establish links between the performance requirements of a process and the possible process changes. She wanted to collect information from its natural environment, yet remain independent of the companies from which she collected data. Her position on the generic research framework offered by Meredith et al (1989) was adjusted to that indicated in Figure 2.3. The research method used was survey research. A full discussion regarding the reasons for adopting this philosophical stance and research method is presented in section 2.6.3.2.

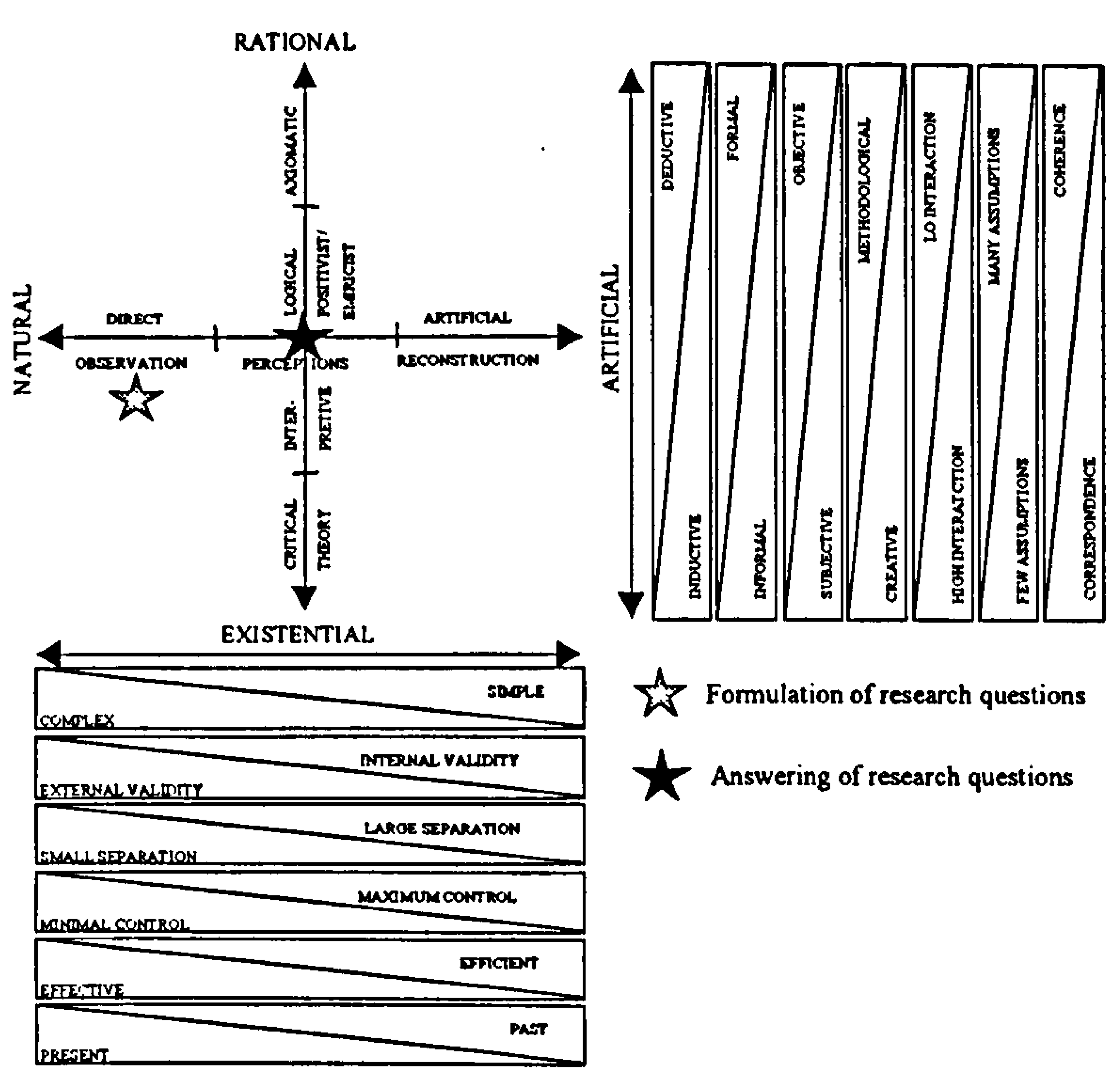


Figure 2.3 - The philosophical stance of the researcher

2.6 The overall research process

The research follows the overall process shown in Figure 2.4 proposed by Sekaran (1992). This takes the research from the initial observation stage, identifying the broad research area through to the validation and testing of whether the research questions were answered. Each of the eight stages is now discussed.

2.6.1 Stage 1: Observation

The prior experience and pre-understanding (Gummesson, 1991) of the researcher as a Manufacturing Engineer led to the identification of business process re-design and performance measurement as general areas of interest. Observations of business process re-design activities undertaken as part of the Manufacturing Engineering role led the researcher to believe that business process re-design activities within companies could be improved through further guidance regarding the changes to make. It also appeared that even though process re-design projects often had lofty goals for improvement, the associated performance of the process was not measured or even considered when re-designing.

2.6.2 Stage 2: Preliminary data gathering

Preliminary data gathering investigates further the broad research area identified and gathers the information required to formulate a problem definition and research questions.

Preliminary data gathering consisted of reviews of business process re-design approaches in both theory and in practice and of the key characteristics of performance measurement systems. The findings of these reviews are stated within this chapter, as they were used when developing the research questions. Full details will be presented in Chapters 3 and 4.

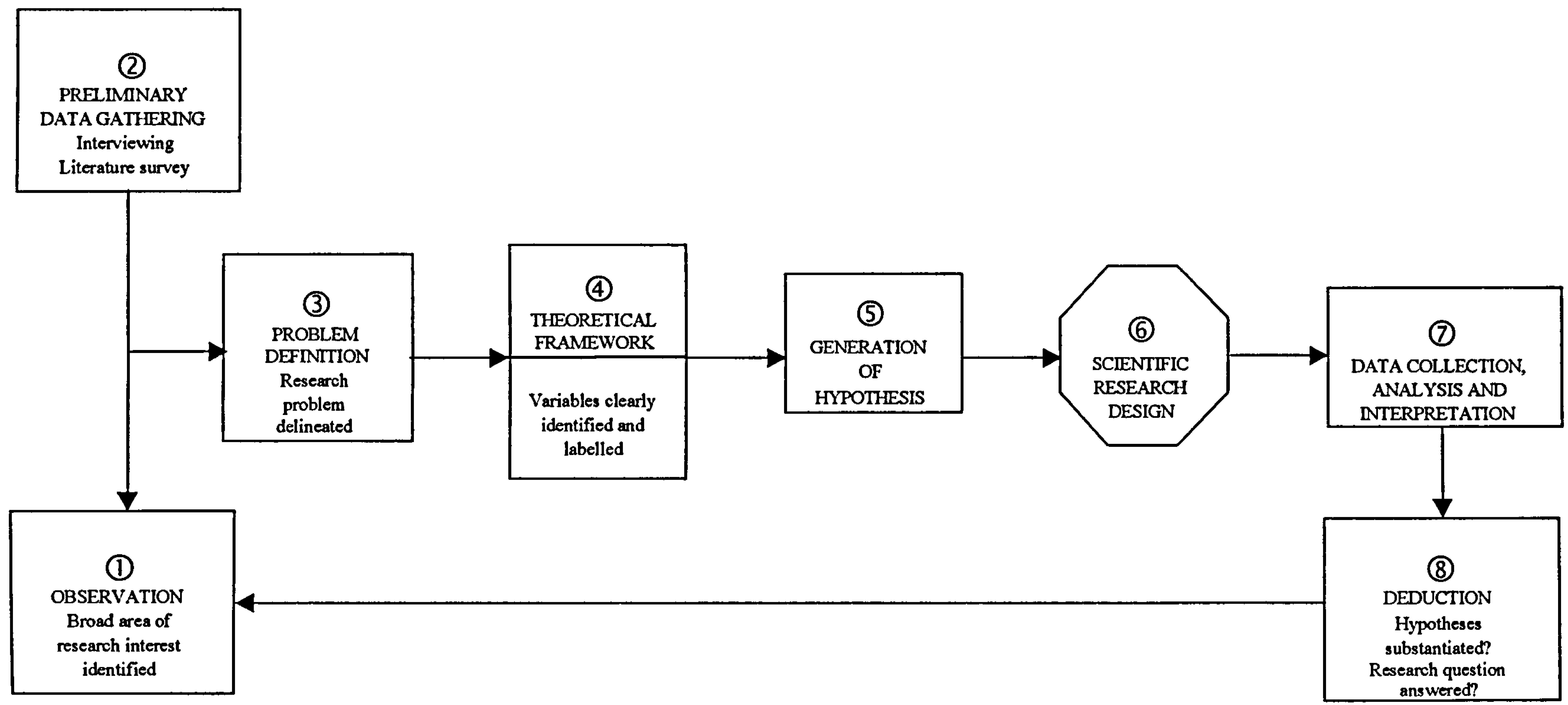


Figure 2.4 - The research process for basic and applied research

2.6.2.1 The theory

The business process re-design literature review investigated current business process re-design approaches with specific regard to the role of performance measurement within them and the selection of process changes. This resulted in the identification of weaknesses and a gap in knowledge to which this research could contribute. In summary the weaknesses were that:

- *Only limited guidance is given on the specific changes that can be made to a process when re-designing it*

  And more importantly,
- *They do not focus on strategically derived performance objectives when re-designing processes.*

The performance measurement literature review identified the characteristics of performance measurement systems that can be used to support business process re-design activities. In summary these were:

- *Strategically derived performance objectives and measures must be adopted to drive the process changes to ensure alignment with the strategy of the organisation*
- *To ensure that a holistic perspective is taken when re-designing processes the Performance Requirements placed on a process must be developed with consideration of the Performance Requirements of the other processes within the organisation*
- *The Performance Requirements must be balanced between the different dimensions of performance so that process performance will not be improved in one area to the detriment of another.*

2.6.2.2 The practice

The researcher wanted to ensure that the results of any research conducted to fill the gap identified within theory would also have a place in the 'real' world. The current business process re-design activities of companies were studied, again with particular regard to the selection of process changes and the role of performance measurement.

The researcher wanted a picture of the business process re-design practices of companies and of the role that performance measurement played within them. The aim was to test whether performance measurement or rather the lack of it was in fact an issue within business process re-design.

2.6.2.2.1 Philosophical stance and associated research method adopted

In terms of the generic research framework shown in Figure 2.1, it was decided that this information would be best collected through direct observation of business process re-design activities within companies. The observations made by the researcher were primarily of the overall business process re-design activities, the perceptions of people involved in the project, the consideration given to performance measurement and the views of those involved in the project regarding performance measurement. These observations were then interpreted by the researcher in the context of the research. The philosophical stance for this stage of the research was that of an interpretivist making direct observations of object reality. Possible research methods appropriate to this philosophical stance, identified from Figure 2.2, are action research and case studies.

Action research is used for theory building, the main aim being to enter an organisation, actively intervene in the problem situation and learn from the results (Hussey and Hussey, 1997). Since at this stage the researcher merely wanted information to clarify the situation within companies action research was not considered suitable.

According to Yin (1994) case study research is an appropriate method where:

- 'How' or 'why' questions are being asked
- The researcher has little control over events
- Phenomena are being investigated within the context of 'real-life'

Since the researcher wanted to observe business process re-design projects within companies to investigate how they were undertaken, case studies were selected as the preferred research method.

2.6.2.2.2 Case studies

The aim of the case studies was exploratory: to ascertain if there was a need for the research. They specifically investigated the role of performance measurement within business process re-design and the selection of process changes. The information was collected through observation, interviews and the study of company literature.

There were four main cases. Three were undertaken as part of a large research project, on which the researcher was employed, the other was undertaken independently within a local manufacturing company. The approach to the two groups of cases was slightly different, though the same information was being sought in both instances.

- How did the company approach process improvement or business process re-design?
- Were performance measures used when undertaking the process re-design or improvement activities?
- Were any difficulties encountered during the business process re-design activities?
- How were the changes to make to a process decided?

The research project cases

The cases undertaken as part of the major research project used unstructured interviews to gather information. Company representatives were asked to talk through the episodes of change that had occurred within the company. The transcripts from these interviews were studied and the information required to address the case questions was extracted. This research project is described fully in Childe et al (2000a).

The independent case

The case undertaken independently by the researcher used observation of business process re-design activities and company documentation to gather the information required to answer the case questions.

The case studies and associated findings will be presented in full in Chapter 3. The findings can be summarised as follows:

- *Companies did not consider the performance required of the process once they started the actual process re-design activities*
- *Process re-design was often unstructured and ad-hoc*
- *Operational performance measures were often used to highlight the need for process change*
- *All the companies appeared to experience some difficulties in their process re-design and improvement endeavours*
- *Process changes were selected according to 'common sense' with little understanding of implications.*

2.6.3 Stage 3: Research questions (Problem definition)

The preliminary information gathered was used to define the research problem and to develop the research questions, this stage of the research also entailed delineating or bounding the research.

To generate the knowledge and fill the gap in current business process re-design approaches the researcher reasoned that if process changes could be associated with specific performance improvements then the relationships established could be used to guide the re-design of business processes. Therefore the following research questions were developed:

1. Is it possible to identify and characterise a set of generic Process Improvement Actions?

2. Can individual improvement actions be linked to specific performance improvements and what are those relationships?

3. If such links can be established is it possible to use them to direct appropriate actions in process re-design, to achieve the performance targets set for the process?

In order to answer the main questions above the following sub-questions were also developed:

- *What are the possible Process Improvement Actions?*
- *What are the possible performance improvements?*
- *What is the role of performance measurement within process re-design?*
- *What performance improvements can be gained from each of the Process Improvement Actions?*

2.6.3.1 The scope of the research

The research outlined within this thesis is concerned with the re-design of business processes within manufacturing organisations. To undertake such research and answer the research questions for all business processes within a manufacturing organisation would not have been practical, therefore the scope of the research was limited to the 'Make Product' process (Weaver, 1995).

The results of this research should therefore be applicable to business process re-design teams specifically concerned with the re-design of the 'Make Product' process.

The primary reason for selecting the 'Make Product' process was that it is the business process of which the researcher has the most experience and pre-understanding.

The position of the 'Make Product' process in a generic process hierarchy is shown in Figure 2.5. Specifically the research does not include the planning of work or the purchasing of parts, despatching of work or process monitoring, nor does it include the technical details of how individual activities are performed.

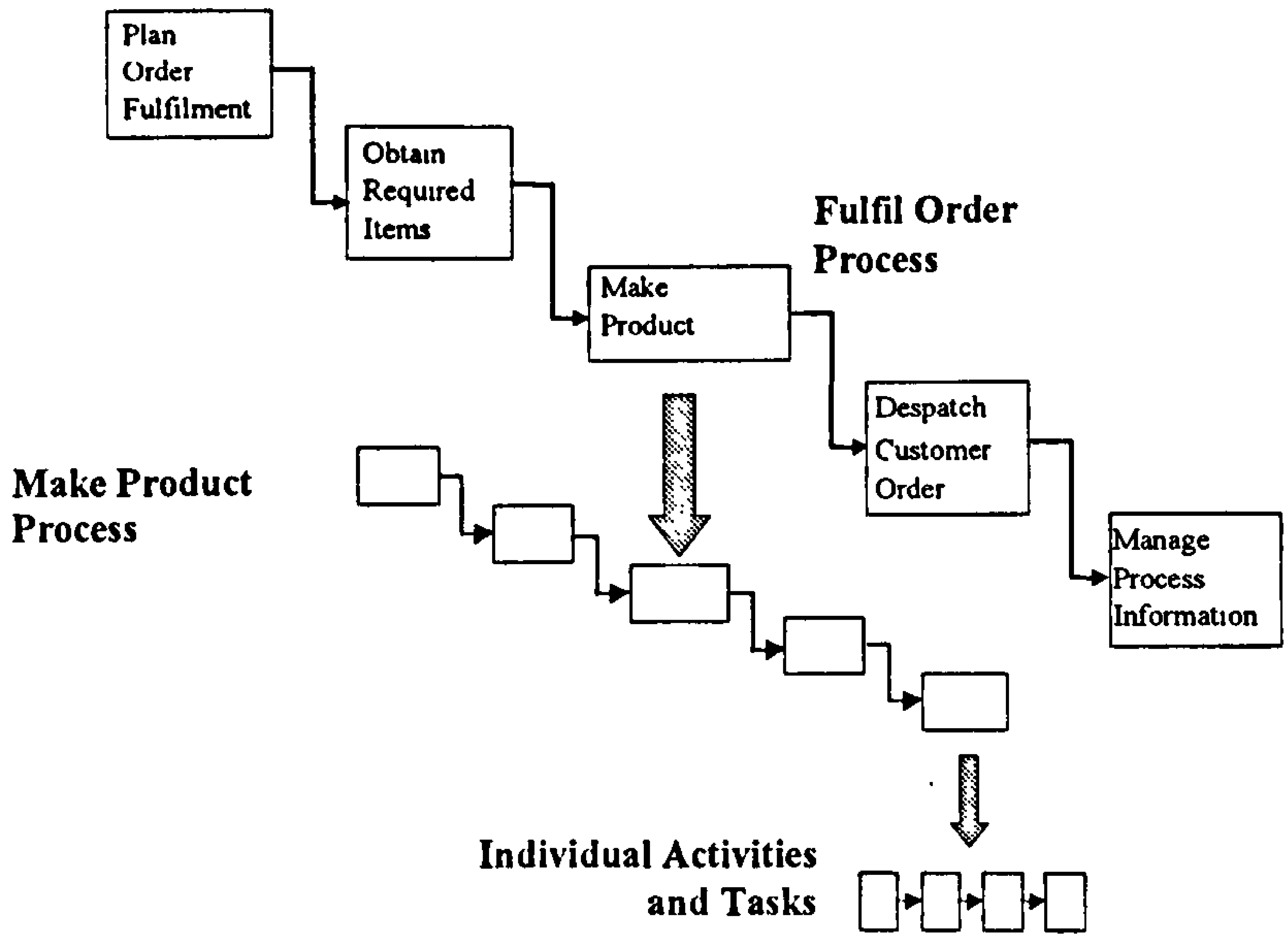


Figure 2.5 - The scope of the research

2.6.3.2 Philosophical stance and associated research method adopted

The philosophical stance adopted by the researcher in order to answer the research questions was dictated primarily by the nature of the information required.

The nature of the information required

Business process re-design projects are affected by many contextual issues unique to the project or the company. Whilst these are of extreme importance to the individual company in their process re-design endeavours they would not be constructive in this research. The researcher had no wish to gather information on the particular experiences of people or companies but to harness the knowledge of individuals to answer some specific questions regarding the 'Make Product' process in a manner that was context-free. The researcher acknowledges that the opinions of those experts may have been coloured by past experiences of business process re-design projects.

It was also a conscious decision on the part of the researcher not to become embroiled in details of business process re-design projects and to maintain an independence from the people and companies from which she required information. Again to become submerged in the individual re-design projects would have resulted in more detailed information but not the context-free type required.

The researcher wished to remain independent from the organisation, yet wanted to collect information from a natural rather than an artificial environment thus positioning her in the perceptions perspective of the natural/artificial continuum shown in Figure 2.1. The perceptions or opinions of others regarding the links between Performance Requirements and Process Improvement Actions were sought. The researcher was pragmatic regarding the information required and wanted it to be context-free indicating a logical positivist/empiricist perspective on the rational/existential dimension. However due to the exploratory nature of the research and because opinion rather than fact was being sought the researcher tended towards the interpretivist end of the positivist perspective. The researcher placed herself in the centre of the research framework for this stage of the research.

Appropriate research methods to use in these circumstances, to collect the opinions of experts, independent of context were:

- In the positivist stance: survey research and structured interviewing
- In the interpretivist stance: historical analysis, Delphi, intensive interviewing, expert panels and scenarios

Of the research methods available within the interpretivist stance Delphi and expert panels were considered, both of these approaches being a method of '*....obtaining and consolidating expert opinions.*' (Meredith et al, 1989). These two research methods were rejected primarily for reasons of practicality. Typically these approaches require a large amount of administration and due to the repeated rounds of inquiry take some time to reach a conclusion.

As far as the positivist stance is concerned structured interviewing was rejected, again on the grounds of practicality. Whilst interviewees with the relevant experience could be identified the logistics of accessing them to conduct the interviews was prohibitive.

The research method adopted was that of a survey. This enabled the researcher to access business process re-design experts throughout the world in a time efficient manner. The results of the questionnaire could then be statistically analysed to ascertain the strength of relationships between Performance Requirements and Process Improvement Actions.

The questionnaire was completed by experts in the field and fed back to them for validation, an approach sympathetic to that of Delphi.

The derivation of the variables used in the questionnaire, generation of the hypothesis and the development of the questionnaire are discussed in sections 2.6.4, 2.6.5 and 2.6.6.

2.6.4 Stage 4: Theoretical framework

This stage of the research entailed the derivation of the variables to be investigated and with regard to the Process Improvement Actions addressed the first of the research questions. This stage was not undertaken independently as suggested in Figure 2.4, but in conjunction with hypothesis generation and research design.

Appropriate variables were derived through detailed literature reviews of business process re-design and performance measurement as outlined in full in Chapters 5 and 6. The Process Improvement Actions and Performance Requirements and their definitions were further refined as a result of the pilot and preliminary phases of questionnaire design undertaken in stage 6.

2.6.5 Stage 5: Generation of hypothesis

This stage was not undertaken independently as suggested in Figure 2.4, but in conjunction with the research design. Whilst the initial hypotheses tested by the questionnaire were developed at this stage, those concerning the relationships between Performance Requirements and Process Improvement Actions were refined through preliminary testing of the questionnaire.

The over-riding hypothesis or proposition put forward by the researcher is reflected in the second of the research questions, *'Can individual improvement actions be linked to specific performance improvements and what are those relationships?'*

The key aim of the questionnaire developed in stage 6 was to test this hypothesis and ascertain whether some relationships could be established.

The questionnaire also presented possible links between Process Improvement Actions and Performance Requirements. Establishing the strength of these links, as the final questionnaire did, was secondary in importance to testing the key hypothesis.

2.6.6 Stage 6: Scientific research design

As discussed in section 2.6.3.2 the research method adopted to address the research questions was that of survey research through the use of a questionnaire. This stage entailed the design, testing, and administration of the questionnaire used and is described in full in Chapter 7.

The questionnaire developed sought the opinion of process re-design experts regarding the relationships between Performance Requirements and Process Improvement Actions.

The key concerns within survey research are those of validity and reliability. Careful design of the survey instrument, in this case a questionnaire, improves its validity and reliability.

The validity of a questionnaire is concerned with the degree to which it performs and measures as it is supposed to (Davis, 2000) There are three main types of validity applicable to survey based research; these are content, construct and criterion-related validity.

Content validity

Content validity is concerned with the degree to which the questionnaire contents represent the topic being studied (Emory 1985, Davis 2000).

Construct validity

Construct validity is a measure of how well the scale being used represents and behaves like the concept being measured (Davis, 2000).

Criterion-related validity

Criterion-related validity is concerned with the extent to which the scale is able to predict the future level of a variable (Davis, 2000).

Questionnaire reliability

The reliability of the questionnaire is concerned with the *'consistency and stability of a score from a measurement scale.'* (Davis, 2000) and thus how reproducible the results of the survey are.

The questionnaire was subjected to several rounds of testing before the final format was decided. These pilot and preliminary stages were used to ensure that the variables contained within the questionnaire (Process Improvement Actions and Performance Requirements) were suitable, that the questions used were appropriate, that the wording was correct and that the questionnaire was understandable.

Focus groups and cognitive laboratory interviews (Fowler, 1993) were used to test the preliminary and pilot questionnaires. Production/manufacturing managers, engineers and academics with process re-design, production management and performance measurement expertise completed the questionnaires. Information was then gathered from them regarding their comprehension and understanding of the questionnaire, how easy they found it to complete and the wording used.

2.6.7 Stage 7: Data collection, analysis and interpretation

The sample from whom the data was collected, the response rate to the questionnaire, the statistics used for analysis and the assumptions made when interpreting those results are key considerations within this stage and are outlined in Chapters 7, 8 and 9.

The way in which data was collected, analysed and interpreted is clearly stated within the research to allow those reading the results to understand the implications of the findings and to enable future researchers to replicate the study if desired. It also has an affect on the validity of the questionnaire.

2.6.8 Stage 8: Deduction/validation

This stage entails the consideration of whether the research questions have been answered and validation of the research findings.

There were two ways in which it was decided whether or not the research questions were answered. Firstly through the interpretation of the research findings by the researcher and secondly through validation by the practitioner.

The researcher's interpretation of the findings with regard to the research questions can be found in Chapter 11, the conclusion of this thesis.

The research findings were validated on the grounds of content and whether they were successful in addressing the needs of the practitioner.

Validation was achieved through the use of a second questionnaire that was sent to process re-design experts who had completed the original questionnaire. This validated the results and also checked for their agreement with the consensus. Questionnaires were also sent to those who had agreed to participate but had not returned the original questionnaire. It was felt that some may have the knowledge of business process re-design necessary to provide constructive feedback.

2.6.8.1 Content

It was stated at the beginning of this chapter that any relationships between Performance Requirements and Process Improvement Actions established should be treated as suggestions and not as fact. However those established do need to be checked for validity. If they are not considered valid then it should be questioned whether relationships could be established and used in a process re-design approach.

2.6.8.2 Practitioner needs

Thomas and Tymon (1982) identified five needs that make the findings of research useful to practitioners. These are descriptive relevance, goal relevance, operational validity, non-obviousness and timeliness.

Descriptive relevance

Descriptive relevance is concerned with the accuracy of the research findings in addressing the problems experienced by the practitioner in their organisation. The findings must address the problem as encountered in the 'real' world, not as encountered in a simplified experiment.

It can also be described as the external validity of the research findings (Campbell and Stanley, 1963).

Goal relevance

Goal Relevance is concerned with how successfully the practitioner can apply the findings of the research to the problem they encounter. The practitioner has an objective to meet within the company; the findings of the research should help the practitioner to meet this objective.

Operational validity

Operational Validity is concerned with the ability of the practitioner to actually use and implement the results of the research.

Non-obviousness

Non-obviousness is concerned with the degree to which the outcome of the research is different from existing methods or common sense that the practitioner might already use.

Timeliness

Timeliness is concerned with whether the outcome of the research is available to the practitioner whilst they are still facing the problem that the research addresses.

Validation against these criteria is presented in Chapter 10.

2.7 Conclusion

This chapter started by introducing the overall aim of the research and the associated nature of the study. It then went on to present the background to the research problem and stated the questions being addressed; this was defined further by limiting the scope of the study to the 'Make Product' process. The alternative philosophical stances available to the researcher were explained and the philosophical stance and associated research methods adopted for specific stages were stated. An eight-stage research process was followed in the research. This chapter gives an overview of each stage. Complete details appear in the rest of the thesis.

Chapter 3 - Current business process re-design approaches

This chapter presents the literature review conducted in the area of business process re-design. The aim was to investigate the various approaches for business process re-design available and the role that performance measurement plays in them. It resulted in the identification of weaknesses in current business process re-design techniques, both radical and incremental and of opportunities where performance measurement may support re-design activities.

The chapter also describes empirical research that was carried out in the form of case studies to investigate business process re-design approaches and the role of performance measurement within companies.

3.1 Business process re-design

In the context of this research, business process re-design is seen as a specific stage within business process re-engineering or business process improvement efforts. It is concerned with the way that the existing 'as-is' process is configured or reconfigured to form the new 'to-be' process. It is one of the common stages of business process re-engineering as identified from the literature and shown in Figure 3.1. A short description of each stage is given in this section, distilled from the approaches of Davenport and Short (1990), Davenport (1993), Guha et al (1993) and Smart et al (1998).

Strategic vision

The re-engineering effort should be aligned with corporate goals and strategies and specific objectives developed. Such objectives may include time reduction, cost reduction, quality, and organisational learning (Guha et al 1993, Davenport and Short 1990). Performance goals should be set for each of the objectives (Coulson-Thomas 1994).

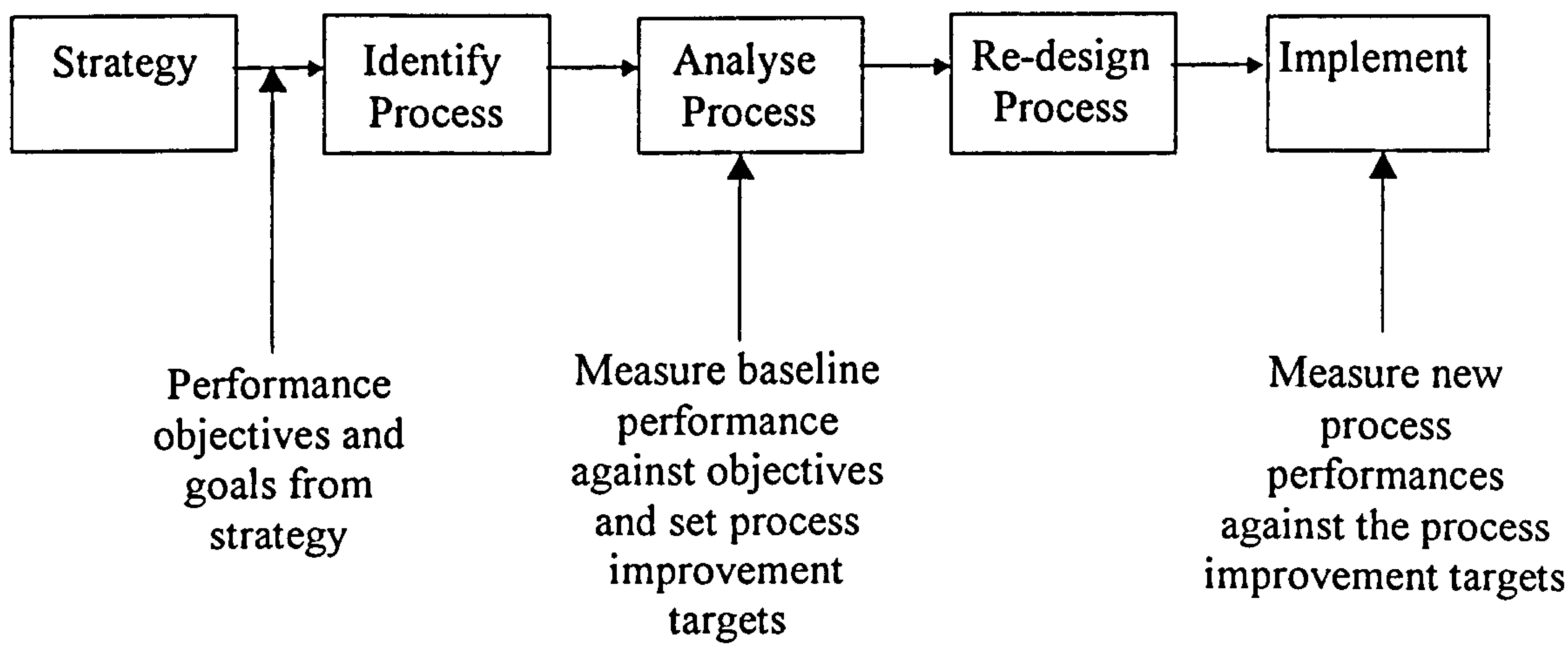


Figure 3.1 - Common stages of a business process re-engineering project

Identify process

The process or processes to be re-designed must be identified. The processes most vital to the organisation or most in conflict with the business objectives can be selected (Coulson-Thomas 1994).

Analyse process

The existing process should be measured prior to re-design and any weaknesses and fundamental problems identified. Process performance is then measured in terms of the new process objectives and targets for the re-designed process set (Guha et al 1993, Davenport and Short 1990, Coulson-Thomas 1994). If the re-engineering project is to be focused on the implementation of new information technology systems, IT led, then the role of IT within the existing process may be assessed at this stage (Guha et al 1993, Davenport and Short 1990).

Re-design process

The 'as-is' process must be re-designed, resulting in a new improved process. How this is undertaken depends on whether a radical or incremental approach is taken. If radical the new process will be designed from scratch, but ensuring that any weaknesses and problems identified in the existing process are avoided. This may be driven by a set of re-design guidelines as offered in the literature (Hammer and Champy 1993, Davenport and Short 1990). If an incremental approach is taken the existing process model will be altered to eliminate any weaknesses and improve efficiency and effectiveness through the application of streamlining tools as offered by Harrington and Harrington (1995) and Womack and Jones (1996).

Implement

The re-designed process is then implemented. In the case of the IT led approaches (Guha et al 1993, Davenport and Short 1990) the re-designed process may be prototyped prior to implementation. Once implemented the new process will be measured in accordance with the process objectives to assess the success of the re-design.

3.2 The focus of the literature review

As stated in section 3.1 the focus of this research is on the re-design of business processes. The re-design stage is also the primary focus of the literature review. However the literature review considers other stages as necessary, where the results inform the re-design. In particular the results of the 'as-is' analysis may inform the changes made in the re-design.

The role of performance measurement in re-design and the origins of the measures are also considered, for example are they derived from strategy?

3.3 Alternative approaches to business process re-design

There are alternative approaches to the actual re-design of a process. These can generally be divided into radical and incremental approaches (Childe, 1995). The main alternatives are outlined within this review. They are discussed with specific reference to the role of performance measurement, the guidance offered in the development of alternative processes and the ability to generate processes that meet specific performance requirements.

3.3.1 Radical business process re-design

There are several authors whose approaches to re-engineering include a radical re-design of business processes.

According to Davenport (1993) a radical re-design approach is *'largely a matter of having a group of intelligent, creative people review the information collected in earlier phases of the initiative and synthesise it into a new process.'* This information includes the process vision, performance objectives and attributes, opportunities and constraints. The re-design team can then brainstorm alternative processes. Though process maps may have been produced when analysing the existing process the new process is designed from a clean sheet of paper, an approach supported by Hammer and Champy (1993). Guha et al (1993) concur that re-design requires creativity and that it should not be governed by existing procedures and principles. To help with the 'creative' re-design Hammer (1990) suggests some general principles for processes, such as organising around outcomes and having one person perform all of the tasks in a process or capturing information only once, at source.

Harrington and Harrington (1995) suggest that the process be designed with the lowest number of activities required to transform the process inputs into outputs. Similar guidelines that are suggested by other authors are presented in Chapter 5 when deriving generic Process Improvement Actions. Guha et al (1993), Davenport (1993) and Harrington and Harrington (1995) all stress the role of information technology in supporting the re-design of the new process.

The alternative processes generated are subjected to feasibility, risk and benefit assessment and compared to the existing state. Companies can use design criteria for evaluating an alternative design such as the likelihood that it will satisfy the chosen design objectives, simplicity, control and the balance of resources (Davenport and Short 1990). The optimum design may then be selected and prototyped or implemented.

Radical approaches to re-design include strategically derived performance objectives and measures for processes, developed from the strategy of the organisation or change programme. These measures are used to establish the baseline performance of the existing process, inform the selection of a new process from alternatives and assess the success of the new process once prototyped, simulated or implemented in the 'real' world.

However the actual re-design relies on the creativity and ingenuity of the re-design team to develop an innovative new process. In the words of Hammer and Champy (1993) re-engineering '.... *demands imagination, inductive thinking and a touch of craziness.'* This is facilitated by guidelines that outline the desirable characteristics of a 'good' process such as Organise around outcome, not tasks and Have those who use the output of the process perform the process (Hammer, 1990). Any knowledge regarding fundamental problems that were identified in the existing process is also considered. It does not consider the performance objectives and measures developed from the strategy. Therefore any focus on strategic performance objectives and improvements may be lost, and the process re-design no longer linked with strategy.

3.3.2 Approaches stemming from radical business process re-design

Discontinuous Transformations (Jain et al, 1994), Goal-based Process Analysis (Lee, 1993) and Results-driven Process Design (Mandrish and Schaffer, 1996) were developed to address this lack of guidance and to introduce some order into radical process re-design, however they have not fully resolved the issue.

Jain et al (1994) developed Discontinuous Transformations as a method for creating innovative business processes from a model (structured process diagram) of the original business process. They considered that the guiding principles suggested by authors such as Hammer and Champy (1993) '*....are vague statements about goodness of a process, but fall short of specifying a concrete methodology of redesigning.*' With Discontinuous Transformations Jain et al (1994) attempt to formalise what they consider to be the '*....traditionally ad-hoc process to performing BPR.*'

Jain et al (1994) believe that Discontinuous Transformations offer a re-design approach that facilitates the creation of innovative business processes by triggering creativity. The new process is however built from the 'as-is' process in a similar way to incremental re-design approaches. The 'as-is' model is subjected to a number of possible transformations. The transformations that Jain et al (1994) propose can be made to a process by relocating, aggregating or making concurrent the activities of the process. Someone with the relevant knowledge then assesses the possible new process for validity. If valid the transformation is applied and the process re-designed accordingly.

Discontinuous Transformations suggest specific changes that can be made to a process and offer some justification for them, in terms of the improvements that can be gained from applying them, for example activities that involve several long lead-time activities may be made concurrent, thereby reducing the elapsed time.

However the transformations suggested constitute only a fraction of the possible changes that can be made to a process in order to improve it. The focus of the re-design is on testing the feasibility of the transformations on the process being re-designed and thus triggering the creativity of the re-design team. There is no consideration made of strategy or of the performance requirements of the process and the likely performance of the new process remains unknown.

Lee (1993) believes that a majority of the work in the area of process re-design does not '*....offer a systematic method for identifying places for improvement and suggesting alternatives.*' Therefore he developed Goal-based Process Analysis which he believes goes some way to doing this. Goal-based Process Analysis is a software-based approach to systematically analyse and re-design processes, investigating alternative processes for achieving a specified set of objectives.

The objectives are expressed in terms of qualitative goals for the process. A hierarchy of sub-processes and sub-goals is developed which essentially models the way in which the overall process goals are achieved. The resulting hierarchy is then tested with a set of rules that identify missing goals, identify non-functional sub-processes and suggest new alternative processes. A database of previous hierarchies is used to identify alternative ways of achieving the goals for the process being re-designed. The resulting process will be made up from a set of activities, linked in a logical manner so that when implemented they should achieve the goal. However there is no component of performance considered in the goal and no way of assessing how well the process will perform in meeting it, a weakness acknowledged by Lee (1993).

Kueng and Kawalek (1997) suggest an approach to process re-design similar to that of Lee (1993) in that a process is built up from goals, the activities required to meet them and the logical dependencies between them. However, Kueng and Kawalek (1997) apply measurement criteria to the goals in an attempt to evaluate the degree to which they have been met. They aim to assess whether the business process designed is a 'good' business process prior to implementation; a good process being one that satisfies the defined process goals. To test this they selected process goals from the characteristics of a 'good' process as detailed in business process re-engineering literature and identified the possible ways in which they might be achieved. For example a process with the goals of 'low operational cost' may be achieved through having a 'high proportion of automated activities' or 'few non-value adding activities'.

Kueng and Kawalek (1997) concluded that a process model could be only partially evaluated during its creation, i.e. prior to implementation. They could not capture all of the process goals and since they were working with and evaluating process models, some aspects of the real world may have been included and others omitted. Also though measures are established for goals and activities it is not made clear how these might be assessed prior to implementation whilst still developing the process model.

Mandrish and Schaffer (1996) developed Results-driven Process Re-design, believing that re-engineering as advocated by Hammer and Champy (1993) was *'impractical and unworkable'*. Results-driven Process Re-design begins with identification of the most urgent business performance improvements and the performance results required. The processes to be changed to achieve these improvements are selected and specific improvement goals set. The re-design team then develops an 'as-is' model of the process, designs improvements to meet the performance goals and implements them. The results are monitored and fed back to inform future process re-design. Mandrish and Schaffer (1996) claim that the performance goals of the process are used to drive the actual process re-design. However no indication is given regarding how to change a process to meet these goals.

3.3.3 Incremental business process re-design

The main alternative to the radical re-design of business processes is an incremental re-design. This entails the design and implementation of small process improvement steps.

Harrington and Harrington (1995) suggest an incremental approach to the re-design of business processes that relies upon the use of streamlining tools. In streamlining the existing process they aim to improve effectiveness (how well the customer expectations are met), efficiency (how well resources are used), cycle time and cost.

The business process is re-designed by systematically applying streamlining tools. The aim of the streamlining tools is to remove waste from the process, smooth the flow of work through the process and improve performance and quality. When a streamlining tool is selected its effect on the process is simulated. The streamlining tools suggested by Harrington and Harrington (1995) include bureaucracy elimination, duplication elimination, value added assessment, simplification, process cycle time reduction, error proofing, upgrading, using simple language, standardisation and supplier partnerships. The process delivering the best performance is selected for implementation. The streamlined process is implemented and then subjected to process measurement to ensure continuous improvement.

An incremental approach to business process re-design is also seen in the work of Womack and Jones (1996) who advocate the use of value-added assessment and the study of process flow in order to reduce waste and streamline processes. Lean Thinking focuses on the reduction of the costs and time absorbed by the process; generic rather than strategically derived performance requirements.

Lee and Chuah (2001) developed a 'SUPER methodology' for business process improvement. This acts as a guide to companies when making changes to an 'as-is' process in order to improve performance. They state that performance measures should be developed and targets set using benchmarking prior to the implementation of process changes. They do not offer any guidance in developing the measures nor do they give any indication as to whether they are derived from strategy.

Rummler and Brache (1990) offer an approach to organisational performance improvement that follows the common stages shown in Figure 3.1. A process is selected for re-design in line with strategy and critical business issues and a re-design team selected and trained. The existing process is then mapped and analysed to identify any 'disconnects'. These include such things as missing, redundant or illogical inputs and outputs. The causes of these disconnects are identified and a new process is designed to eliminate them and streamline the process. This process should be made up from the tasks needed in order to deliver the product or service required by the ultimate customer. The new process is mapped, relevant measures developed and the changes implemented. Rummler and Brache (1990) appear to take an incremental approach to the re-design of a process using an 'as-is' map, eliminating disconnects and streamlining the process.

Do these incremental approaches to re-design display the same lack of guidance and performance focus as identified in the radical approaches? Process improvement methods such as those suggested by Harrington and Harrington (1995) focus on improving the performance of a process, along specific dimensions, typically time, cost and quality. These constitute a generic set of performance objectives that are applied across all processes, rather than specific objectives derived from the strategy of the individual organisation or change programme.

In these approaches, a detailed analysis of the existing process and the application of specific streamlining tools facilitate the actual process re-design. The streamlining tools guide the analysis of the existing process, for example value-added assessment, or suggest general process improvements that could be made, such as error proofing activities. The changes made to a process as a result of the streamlining tools should result in specific process improvements in one or more of the generic performance dimensions on which the approach focuses.

The weakness of incremental approaches is not so much that they lack performance objectives as a driver, but rather that in concentrating on generic performance improvements, they lack strategic focus. Performance improvements will be made, but not necessarily those improvements required for meeting the organisational strategy or objectives.

3.3.4 Process Improvement Actions

The process re-design approaches discussed, both radical and incremental, suggest re-design principles and tools that can be used when re-designing processes. These give some guidance as to the changes that can be made when re-designing and improving a process and are referred to in this research as Process Improvement Actions. There is a vast quantity of literature in the area of process re-engineering and process re-design from which such Process Improvement Actions can be drawn. A generic list of Process Improvement Actions is presented in Chapter 5.

Application of the Process Improvement Actions should result in an improvement in a certain performance requirement categorised under the dimensions of business process performance such as time, cost or quality or flexibility. Occasionally the literature will make a link between a process improvement opportunity and associated performance improvements. Such links are made infrequently and do not direct the process designer in selecting the most suitable course of action.

3.3.5 The weaknesses in current business process re-design approaches

As a result of the process re-design literature review two key weaknesses of current business process re-design approaches were identified:

- *They only offer limited guidance on the specific changes that can be made to a process when re-designing it,*

  and more importantly,
- *They do not focus on strategically derived performance objectives when re-designing processes.*

These key weaknesses apply to some degree in both radical and incremental process re-designs. The process re-design activity becomes a 'black box' into which the existing process is put and from which a new improved process appears. How to undertake the actual re-design within that box is often only alluded to in the process re-engineering and re-design literature. Companies do not know what to change to achieve performance improvements (Love and Gunasekaran, 1997). The re-design of processes to meet specific strategically derived performance improvements requires further research. The work reported in this thesis contributes to this requirement.

3.4 A review of business process re-design approaches within companies

To build a complete and balanced picture of the situation regarding business process re-design approaches an empirical investigation was conducted to complement the theory.

This empirical investigation took the form of some exploratory case studies of business process re-design and process-based change within companies. In Case A the researcher observed a major business process re-engineering project with particular regard to the way in which they approached the re-design of the company, the re-design of the processes within it and the role of performance measurement. The full case can be found in Appendix 1.

To build cases B, C and D the researcher studied transcripts of interviews recorded with three companies concerning their process-based change activities over the previous years. Again these were studied with particular regard to the business process re-design approaches used, the selection of changes and use of performance measures. Relevant excerpts from the transcripts can be found in Appendix 2.

The way in which the cases were conducted and the philosophical stance of the researcher were discussed in Chapter 2.

Case A - A major business process re-engineering project

The first case studied a major business process re-engineering project within a large company. The re-engineering project was initiated by the top management of the company as a response to disappointing performance. It entailed the re-design of the overall structure of the organisation and of the processes within it.

Company A approached business process re-engineering in a very organised manner starting with the formation of a dedicated team to work on the project. This team worked alone in the initial investigative stages but was joined by consultants once the project began in earnest.

During the investigative stages, process maps were developed and used as a basis for discussion to identify the key weaknesses and problems of the company. These included a lack of strategy, too much bureaucracy, high waste, a lack of customer focus and a lack of real processes. As a result they decided to review their strategy and product portfolio and restructure the organisation.

It was decided to restructure the organisation into Value Chains based on common product characteristics and functionality. Each of these Value Chains contained all of the processes required to win their own business, fulfil orders and satisfy their customers. There was also a strategy group, an in-feed group (that supplies the Value Chains) and an infrastructure group. The design of this structure was slow, as the team had to decide whether to select Value Chains on the grounds of product characteristics, customer requirements or technical capabilities. This decision was made harder by the lack of a clear business strategy to guide them and meant that they had to second-guess the strategy or work without it.

The other main issue, possibly linked to the lack of strategy, was a lack of performance measures for the organisation or the project. The process improvement team acknowledged the importance of performance measurement, even developing criteria for successful performance measures; however they did not develop any actual measures. The development of performance measures remained on the 'to-do' list and was always put aside in favour of other work.

The restructuring of the organisation was triggered as a result of poor performance and undertaken to address the fundamental weaknesses applied, but throughout the restructuring there was no clear strategy and no performance measures.

Responsibility for the design of the Value Chains and processes within them was given to the Value Chains themselves with the help of a Change Agent. Each team had its own approach to re-design but was expected to adhere to the principles of Lean Thinking and World Class Manufacturing. These principles gave the Value Chains an idea of the general performance that they should be aiming for, such as 100% satisfaction of customer requirements, reduced waste and increased value. The Value Chains did not develop specific performance requirements prior to re-design but aimed for the general performance targets as advocated by World Class Manufacturing and Lean Thinking principles.

The approach to re-design was different for each Value Chain. Typical stages included the mapping of activities, derivation of customer requirements, identification of weaknesses and waste and the streamlining of processes. Specific performance measures were not considered during re-design.

Company B - The design and manufacture of security products

Company B approached process improvement in an ad-hoc manner. If a problem arose they changed the process to solve that particular problem. They had no process measures so did not know where they stood in terms of performance, but were aware that the processes and systems they used within manufacturing were convoluted and complex. These processes were improved, with operational performance measures put in place to help identify the changes required. However these process changes were not approached in any structured manner, but as the need arose. The manufacturing vice-presidents believed that small companies did not always have the knowledge to understand or make the required changes and were in need of help and guidance.

Company C - The manufacture of sealing systems for door assemblies

Company C used performance measurement to provide feedback about their processes and used this to direct the changes required. Their approach to process improvement and re-design was one of 'common sense', with their selection of process changes made according to what seemed sensible and practical to achieve the desired improvement.

Company D - The fish smokers

Company D had strategy and performance measures but their approach to process improvement and re-design was unstructured and they found it difficult. They acknowledged that process changes were made with little understanding, and performance often improved only to regress later. They would then tinker with the process to improve it once again. As an example, at one time they reorganised their production processes three times within eight months.

3.4.1 Key issues arising from the case studies

The key findings from the case studies were that:

- *Companies did not consider the performance required of the process once they started the actual process re-design activities*
- *Process re-design was often unstructured and ad-hoc. The large company adopted general principles and guidelines to help in the re-design of their processes*
- *Operational performance measures were often used to highlight the need for process change*
- *All the companies experienced some difficulties in their process re-design and improvement endeavours*
- *Process changes were selected according to 'common sense' with little understanding of implications.*

3.5 Summary of findings

The process re-design activities undertaken by each of the case companies are summarised in Table 3.1, in terms of their overall approach to re-design (the driver and scope), the processes being re-designed and the team responsible for undertaking the re-design. The table also compares the re-design activities of the companies against the key weaknesses identified in the business process re-design literature review to ascertain if the same issues arise in both theory and practice.

		Company A	Company B	Company C	Company D
Re-design activities in company	**Driver**	Top down	Top down	Top down	Top down
Re-design activities in company	**Scope**	Radical	Incremental	Incremental	Incremental
Re-design activities in company	**Processes re-designed**	• Complete organisation • Order Fulfilment including the Make Product process	Order Fulfilment including the Make Product process	Order Fulfilment including the Make Product process	Order Fulfilment including the Make Product process
Re-design activities in company	**Re-design team**	• Dedicated team and consultants • Change Agent and process employees	Manufacturing Manager and appropriate employees	Management Consultant and Production Manager	Manufacturing Manager and appropriate employees
Re-design activities in company	**Performance Measures used in company**	Existing measures	None initially, then operational measures	Extensive operational measures	Strategic key indicators
Comparison with weaknesses identified in BPR literature	**Selection of changes in re-design**	According to WCM and Lean principles and through the application of guidelines and streamlining tools	Ad-hoc	Common sense	Unstructured and ad-hoc
Comparison with weaknesses identified in BPR literature	**Role of Performance Measures during re-design**	Limited generic measures e.g. 100% waste reduction	None	None	None

Table 3.1 - A summary of the re-design activities of the case companies and a comparison with the weaknesses identified in BPR literature

When compared, the weaknesses identified in the process re-design literature review and the conclusions of the cases do indicate that there is a need for further research in the area of business process re-design. Such research would focus on the re-design of business processes and the selection of appropriate Process Improvement Actions to meet specific strategically derived performance requirements.

3.6 Conclusion

This chapter began by clarifying the meaning of business process re-design in the context of this research. It went on to present the results of a critical literature review undertaken in the area of business process re-design and business process re-engineering which identified weaknesses in current approaches. Case studies of business process re-design projects within companies were presented and compared to the theoretical weaknesses to verify the need for the research in the 'real' world. It is these weaknesses that the research aims to address by investigating possible links between performance requirements and the changes that can be made to a process.

Chapter 4 - Key characteristics of performance measurement systems

This chapter presents the literature review conducted in the area of performance measurement. The aim of this review was to investigate the link between performance measurement and process re-design and to identify any aspects of performance measurement that may support process re-design activities. It resulted in the identification of the key characteristics of a performance measurement system. This chapter discusses the applicability of these characteristics to business process re-design.

4.1 The field of performance measurement

Performance measurement has been used to monitor and control organisations for many decades, primarily through the use of accounting based financial measures. However in the 1980's both academics and industrialists began to question the suitability of such measures for organisations that were operating in highly dynamic and competitive environments. Johnson and Kaplan (1987) introduced the need of non-financial as well as financial measures of performance, as did Eccles (1991) and Keegan et al (1989) who outlined requirements for 'modern' performance measurement systems. This work was closely followed by the development of frameworks encompassing the key characteristics of modern performance measurement systems (Kaplan and Norton 1992, Lynch and Cross 1995 and Fitzgerald et al 1994).

The requirement for non-financial as well as financial measures broadened the area of performance measurement. This change in mindset regarding performance measures had a significant effect within the field of performance measurement and is recounted in the introductions of many works in the area. It is now a research area of interest not only to the accounting discipline, but also within such areas as Human Resources and Operations and Production Management, and in the case of this research, process re-design.

This literature review does not attempt to encompass the whole field of performance measurement but only the aspects relevant to the research being undertaken. These include:

- The key characteristics of performance measurement systems that support re-design
- The role of performance measurement in process re-design and process improvement

4.2 Common stages in the development of performance measures

It becomes apparent when studying the various approaches available for the development of performance measures, including Neely et al (1996), Kaplan and Norton (1993) and Lynch and Cross (1995) that they incorporate some common stages. The common stages identified can be brought together to draw a generic, though basic approach to developing performance measures, starting with the company's strategy and resulting in balanced, integrated measures which drive all actions towards that strategy.

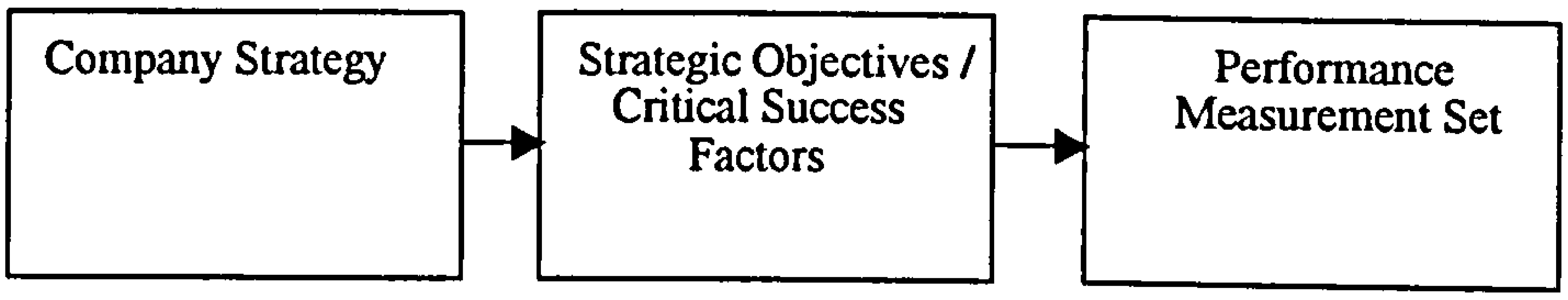


Figure 4.1 - Common stages in the development of performance measures

Writers generally agree that the development of performance measures should start with the strategy of the company. The strategy focuses the company on what it is they are trying to achieve. The key areas of importance can be derived from the strategy as strategic objectives or critical success factors. Once these areas critical to the success of the company have been decided, appropriate measures can be derived for each. Since objectives and performance measures have been derived from strategy they focus company effort onto achieving that strategy. This approach can also be seen in the work of Schneier et al (1991) and Epstein and Manzoni (1997).

The importance of critical success factors within an organisation was introduced by Daniel (1961) who defined them as '... *the three to six factors that determine success; these key* *jobs must be done exceedingly well for a company to be successful.*' This concept was built on by Rockart (1979) who defined critical success factors as '*...the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organisations.*' Boynton and Zmud (1984) undertook an assessment of the critical success factors approach citing both strengths and weaknesses, however they still advocate the use of critical success factors to '*.... facilitate the rapid accumulation of meaningful information.*'

Development of critical success factors is included in many of the methods available for the development of performance measurement systems. Critical success factors are used to link the strategy of the company and the performance measures developed. According to Schneier et al (1991) '*... the essence of the strategy can be distilled into the few factors that must be executed with excellence to gain and sustain competitive advantage.*' These are the factors that should be measured.

4.3 Key characteristics of performance measurement systems

A thorough review of the performance measurement literature highlighted several key characteristics of performance measurement systems. These characteristics were prevalent throughout the literature, the same characteristics being suggested by many authors. These characteristics are:

- *Strategy alignment*
- *Feedback of performance results*
- *Cascading and translating top-level measures to operational measures*
- *Balancing the different dimensions of performance*
- *Measures as an integrated set*

This section outlines each of these characteristics. The characteristics are then compared to a set of core elements of performance measurement systems (Ballantine and Brignall, 1994). These were also derived from the performance measurement literature and comparison with them offers further confidence as to the importance of the characteristics presented.

Strategy alignment

Performance measures should be aligned with the strategy of the organisation. This is a belief that underpins many of the performance measurement frameworks including Kaplan and Norton (1992) and Lynch and Cross (1993) and is also supported in the work of Keegan et al (1989), Eccles (1991) and Globerson (1985).

These strategically derived performance measures can then be used to direct the appropriate actions required in achieving the strategy. They highlight the areas where improvements and action are required so that strategies can be successfully implemented (Maskell 1989, Vitale 1994). Dixon et al (1990) considered the relationship between strategy and measures in some detail as part of their approach for updating and changing performance measurement systems. They highlight the link between strategy, actions and measures. An organisation should have a strategy on which to focus and the relevant actions required for achieving it. Measures should then be put in place to monitor the performance of the actions in achieving the strategy and highlight the need for any changes. The actions and measures are driven by the strategy, however the strategy is also informed by the results of the actions taken.

Wisner and Fawcett (1991), Sink (1993) and Schneier et al (1991) also highlight the role that performance measurement has in supporting the achievement of business strategy by focusing attention on actions that contribute to achieving the strategy and monitoring the progress that has been made.

Another reason for performance measures to be derived from strategy is so that they can influence the behaviour of people within an organisation (Neely et al, 1995). The Balanced Scorecard puts strategy at the centre of the measures, establishes goals and assumes that people will adopt whatever behaviour is required to meet them (Kaplan and Norton, 1992).

The performance measurement system not only indicates the actions required, but can motivate people to take the appropriate actions due to its ability to direct and shape the behaviour of people within an organisation. This is the concept underpinning such sayings as *'What you measure is what you get.'* (Kaplan and Norton, 1992) and *'What gets measured gets attention.'* (Eccles, 1991).

The use of performance measures to direct behaviour is beyond the bounds of this research project, however it should be acknowledged that they are a powerful means of soliciting and directing desirable behaviour (Simmons, 1995).

Finally, the relationship between strategy and performance measures means that if the strategy of an organisation changes then the performance measures must change accordingly. If new measures are not developed, and just as importantly the old obsolete ones discarded, achievement of the new strategy will be impeded (Keegan et al 1989, Dixon et al 1990), in fact measures should change as circumstances change (Maskell, 1989). If current measures are not derived from current strategy they may be focussing attention upon the wrong working areas (Lynch and Cross, 1991).

Feedback of performance measures results

According to Neely at al (1996) the real benefits of performance measures are gained from closing the management loop and ensuring that measures stimulate appropriate actions and improvements in the business. The importance of feedback is explicitly discussed in the performance measurement framework of Fitzgerald et al (1994) and in the work of Dixon et al (1990), Maskell (1989) and Thor (1993.)

Kaplan and Norton (1996) extended their basic Balanced Scorecard into a strategic management system by introducing four new processes. These form a closed loop in which strategy is expressed as an integrated set of objectives and goals that are communicated throughout the organisation. Targets and business plans are set and performance is compared with the targets to direct action and facilitate learning.

Cascading of top-level to operational measures

The performance measures used at the top level of an organisation can be translated down through the organisation, into measures meaningful at lower levels (Epstein and Manzoni, 1997). For example profit will depend on waste at an operational level. Measures are hierarchical and should become more detailed and specific as they cascade down through a company (Keegan et al, 1989). In this way performance measurement should link the top-level strategy of a company to the operational level, so that decisions made at the operational level contribute to company strategy (Wisner and Fawcett 1991, Lynch and Cross 1995). The Performance Pyramid of Lynch and Cross (1995) and the integrated performance measurement system advocated by Bititci et al (1997) are based on this hierarchy of measures from top-level through to operational.

Balancing the different dimensions of performance

The measures used within a company should be balanced between categories and dimensions of measurement. Various categories and dimensions are suggested in the performance measurement literature and whilst the actual measures selected will depend on the company strategy it is accepted that there should be a balance between these. The types of measures used within the frameworks can be summarised as internal, external, financial and non-financial and the dimensions typically time, cost, quality and flexibility. The specific dimensions are used within the frameworks to encourage companies to select measures from each. This ensures that they consider all aspects of performance, giving them an overall picture of health and illustrating the effect that changes in the performance of one dimension can have on the others.

The balance between internal and external measures is discussed by, amongst others, Keegan et al (1989) and Neely et al (1995). This balance prevents companies from concentrating on internal operational measures, without looking at external requirements such as customer satisfaction.

Kaplan and Norton (1992) and Keegan at al (1989) advocate the use of operational as well as financial measures of performance. Whilst they acknowledge that financial measures remain important, primarily for the company's shareholders, the inclusion of non-financial measures offers a broader view of the company performance. Kaplan and Norton (1992) believe that a single measure cannot provide a clear performance target or direct attention to the critical areas of the business so managers require a mix of both financial and operational measures, a view shared by Thor (1993). The balance between financial and non-financial or operational measures is also encouraged by Maskell (1989), Vitale et al (1994), Neely et al (1996) and Lynch and Cross (1995).

Balancing measures between the categories of time, quality, cost and flexibility or similar should prevent companies from concentrating on one category of performance to the detriment of the others or of the company as a whole (Ghalayini and Noble 1996, Fry and Cox 1989, Newing, 1995). A company can see how it is performing across the board and consequently has all relevant information available when making decisions. The strategy of a company may require it to concentrate on one category more than on the others. However if they have considered all categories, any emphasis on one over the others will be a conscious decision and any implications for overall performance will be understood (Kaplan and Norton, 1992).

Measures as an integrated set

The performance measures used by the functions and processes within a company should be developed together, from the strategy, as an integrated set (Vitale et al, 1994). This ensures a holistic view and is preferable to functions or activities developing performance measures in isolation.

Where functions or departments develop measures in isolation, focusing on the improvement of performance in those measures may optimise the performance of that department, yet detract from the performance of another department or sub-optimise the performance of the company overall. Possible conflict is addressed in Fry and Cox (1989) who warn that companies should be aware of how local measures impact on global measures and on other functional areas or departments. Blenkinsop and Burns (1992) suggest that performance measures be designed so that in optimising the performance of a particular group a company does not jeopardise the performance of the company as a whole.

Wisner and Fawcett (1991) believe that an effective performance measurement system will integrate the various areas of a company so that they act together as one co-ordinated value-adding system.

4.3.1 Confirmation of the characteristics

Ballantine and Brignall (1994) compiled a taxonomy of performance measurement frameworks in which they identified what they perceived to be five core elements of performance measurement systems, a control model, level of organisational analysis, multiple dimensions of performance, integration and information technology. They analysed several of the performance frameworks referenced within this chapter against the core elements and concluded that each core element is included explicitly or implicitly within each framework.

The key characteristics described in section 4.3 and the core elements are outlined and compared in Table 4.1. It can be seen that the key characteristics identified in the literature review correspond to the core elements for a performance measurement system. The exception is information technology. This was not identified as a key characteristic of performance measurement systems during the literature review as the research being conducted concentrates on the development rather than the implementation of performance measurement systems.

Key Characteristics	**Core Elements** (Ballantine and Brignall, 1994)
Measures should be derived from and aligned with the strategy of the company.	The core process elements: the requirement for a control model and the specification of the organisational level being measured embrace three of the key characteristics. Performance measurement should link strategy to operational plans using feedback to monitor progress and feed-forward control to predict future outputs. It should be clear which level of an organisation is been measured and measures may vary between levels.
Measure results should be fed back in order to monitor progress and trigger action.	
Strategic measures should be cascaded down to an operational level.	
Measures should be balanced between several dimensions of performance.	There should be multi-dimensional performance measurement including financial/non-financial, internal/external and qualitative/quantitative measures.
Measures should be derived as an integrated set rather than by individual departments or functions in isolation.	A Performance Measurement System should be developed as a holistic system.
	An effective IT infrastructure is required in order to implement the performance measurement system developed.

Table 4.1 - Key characteristics and core elements of performance measurement systems

4.4 The role of performance measurement in business process re-design

A majority of the performance measurement literature discussed within this review was developed with regard to functionally based organisations. There has been less generated specifically for process based organisations. Von Bonsdorff and Andersin (1995) and Lockamy and Cox (1994) believe that the change from functional to process based organisations and management implies that performance measurement should also shift to align with business processes.

Kueng (1998) developed a performance measurement system to support business process re-engineering, concentrating on measurement to ensure high levels of process performance in the longer term, achieved through continual assessment and feedback of process performance.

Some authors specifically discuss the role of performance measurement in the re-design or improvement of business processes. Kaplan and Norton (1993) believe that performance measures can successfully be used to drive the process of change and to provide a shared understanding of goals and what it takes to achieve them. They believe that a balanced scorecard can serve as a focal point for improvement initiatives such as re-engineering, helping to define and communicate priorities. In case studies conducted by Kaplan and Norton (1992, 1993) the Balanced Scorecard is at its most useful when driving change. It allows an organisation to identify and concentrate on improving or re-engineering those processes most critical to strategic success and provides a shared understanding of goals. Rummler and Brache (1990) agree that performance measurement can be used in the management and improvement of processes. Lynch and Cross (1995) believe that performance measures are the most powerful single means to ensure successful implementation of change actions and according to Ostroff and Smith (1992) performance measurement is the key to implementing horizontal, process based organisations.

4.5 Using performance measurement system characteristics to support business process re-design

Performance measurement plays an important role in supporting the re-design and improvement of business processes. Performance measures can be used to communicate the improvement priorities of an organisation, to promote a shared understanding of improvement goals, to monitor performance and through the feedback of results to indicate when actions are required to improve performance. However, the actual actions required to achieve the performance improvements are not specified within performance measurement literature. This research aims to link the requirements for performance improvement to the improvement actions that are suggested in business process re-design literature.

The performance measurement literature review also identified several common characteristics of performance measurement systems: strategic alignment, feedback, cascaded, balanced and integrated. The relevance of each of the key characteristics to business process re-design is explained in this section.

Strategy alignment and feedback of the results

The development of performance measurements from the strategy of an organisation ensures that the strategic priorities are highlighted and through the performance measures adopted it ensures that these are the areas in which effort is concentrated in order to achieve the strategy. In this way the strategically derived performance measurements direct and drive the actions of the organisation. The results of these actions are measured and fed back to indicate the degree of success in achieving the strategy and to direct future actions. The need for strategically derived performance measures to direct actions and the feedback of results to assess success is important when re-designing business processes. If a re-designed process is to contribute to the improved performance of the organisation then the performance objectives and the measures placed on it must be drawn from the strategy of the organisation or associated change programme. The process changes made should then be driven by these performance objectives and measures thus improving the performance of the process in line with that required by the strategy. Success can be assessed and the results fed back to inform future process changes.

Cascading of top-level to operational measures

The top-level measures are cascaded down to process level, activities and ultimately individuals, but in a form meaningful to each level. This ensures that any actions taken or in the case of process re-design any process changes made will be in alignment with organisational strategy.

Balancing the different dimensions of performance

The performance objectives and measures applied to a process for re-design should also be balanced between the possible dimensions of performance. Optimising process performance along one dimension such as time may have a detrimental effect on another performance dimension such as quality. Therefore process performance improvements should not be undertaken without considering the effect that each dimension of performance has on the others. The possible performance dimensions of time, cost, quality and flexibility that are common to many performance measurement systems can be used to categorise the performance objectives and measures used in process re-design.

Measures as an integrated set

When re-designing a process, though it may be re-designed in isolation, there could be an effect on the performance of associated processes and the company as a whole. Optimising the performance of one process in isolation will not necessarily lead to improvements in the performance of the company overall and may lead to poorer performance in associated processes. This can be overcome by looking at the company holistically and deciding process performance requirements and measures for all processes together as an integrated set and in line with the top-level strategic measures.

The performance objectives and measures developed for use when re-designing processes should be cascaded to the appropriate level, balanced and integrated as with those in a performance measurement system. These characteristics will promote a holistic approach to process re-design in which the relationships between the processes and the organisation as a whole are considered.

In summary, applying the characteristics common to performance measurement systems when developing the performance objectives and measures for use in process re-design will mean that:

- *Strategically derived performance objectives and measures must be adopted to drive the process changes to ensure alignment with the strategy of the organisation*
- *To ensure that a holistic perspective is taken when re-designing processes the performance objectives placed on a process should be developed from strategy and with consideration of the performance objectives of the other processes within the organisation. This is to prevent optimising the performance improvement of one process in isolation to the detriment of any inter-related processes or the organisation*
- *The performance objectives and measures must be balanced between the different dimensions of performance so that process performance will not be improved in one area to the detriment of another.*

4.6 Conclusion

This chapter reviewed the key literature in the area of performance measurement drawing out the key characteristics of performance measurement systems, namely that they should be strategically aligned, cascaded, balanced, integrated and have feedback mechanisms. The applicability and importance of these to business process re-design was then discussed, as was the role of performance measurement in business process re-design.

Chapter 5 - Process Improvement Actions

This chapter introduces Process Improvement Actions, that is those changes that can be applied to a process in order to improve its performance. Process Improvement Actions are suggested throughout business process re-design and re-engineering literature, in which they are referred to as tools, guidelines etc. These suggestions are expressed in different ways by different authors even if the same change is being outlined. A common description of each is therefore needed to provide a starting point for grouping the actions and deriving generic Process Improvement Actions. These are then defined. The generic Process Improvement Actions and associated definitions are required to make the links with performance measures that are key to this research project.

5.1 Derivation of the Process Improvement Actions

There is much literature available within the field of business process re-engineering, business process re-design and process improvement. The Process Improvement Actions were gathered from a sample of this literature and are listed in Figure 5.1. The sample contains key texts and a point was reached where no new suggestions were emerging. It was on this basis that the sample was considered sufficient. Similar words or phases within the titles were then used to group common Process Improvement Actions and a description of each was generated. In some cases suggestions in the literature were not considered further as they did not constitute Process Improvement Actions as defined in section 5.2. Through the description of each of the common Process Improvement Actions it became apparent that again some were discussing the same process change. These were grouped into an initial list of generic Process Improvement Actions and definitions later refined as a result of the preliminary and pilot questionnaire as described in Chapter 7.

Figure 5.1-Process Improvement Actions (1 of 2)

Armistead, Harrison, Rowlands (1995)

- Organise around outcomes not tasks
- Have those who use the outcome of the process perform the process
- Trust geographically dispersed resources as though they were centralised creating hybrid centralised/decentralised organisations
- Link activities in natural order and perform them in parallel
- Perform work where it makes most sense particularly decision making, information processing, checks and controls making them part of the process
- Capture information once at source, minimising reconciliation
- Combine several jobs into one possibly creating a case manager as a single point of contact
- Create multiple versions of processes possible

Ballé (1995)

- Delegate decision making to the workplace
- Empower Teams
- Value added analysis
- Eliminate entry/re-entry of data (automate where possible)
- Reduce hand-offs from one person to another
- Separate work-items going through the process in terms of how long they take to process
- Negotiate with suppliers for faster response
- Case worker or case team (No-one in charge)
- Obsolete assumptions
- Too many checks and controls
- IT as an enabler (check process first)
- Don't automate, eliminate
- Think parallel
- Split processes
- Work where it makes most sense, in the order that it makes most sense

Harrison and Pratt (1993)

- Concurrency
- Displacement
- Extended Enterprise Concepts
- Simplification

Watson (1994)

- Process elimination
- Process time compression
- Process concurrency
- Process first pass yield increase
- Reduce cost (without detriment to cycle time)

Kueng and Kawalek (1997)

- Maximise the degree of parallel running activities
- Limit checking and control activities to the extent that they make economic sense
- Performance measurement points should be close to the activity
- Checking activities (fault detection) should be near the source
- Compress formerly distinct tasks into an integrated and compressed one
- Those who use the output of a process should perform the process
- In good business processes human actors carry out a meaningful and integrated job
- Processes with multiple paths (beginning with triage)
- Few interaction between roles they do not add value and introduce delays : Add extra decision making, higher skill level, Restructure the roles
- Human actors have possibility for social interactions
- Documented and well defined process

Hammer and Champy (1993)

- Several jobs are combined into one
- Workers make decisions
- The steps in a process are performed in a natural order
- Processes have multiple versions
- Work is performed where it makes most sense
- Checks and controls are reduced
- Reconciliation is minimised
- A case manager provides a single point of contact
- Hybrid centralised/decentralised operations are prevalent
- IT - Information can appear in many places simultaneously
- IT - A generalist can do the work of an expert
- IT - Businesses can be centralised and decentralised
- IT - Decision making is part of everyone's job
- IT - Field personnel can send and receive information wherever they are
- IT- The best contact with a potential buyer is effective contact
- IT - Things tell you where they are
- IT - Plans get revised instantaneously
- As few people as possible should be involved in the performance of the process

Figure 5.1-Process Improvement Actions (2 of 2)

Hammer (1990)

- Organise around outcomes, not tasks
- Those who use the output of the process perform the process
- Subsume information processing work into the real work that produces the information
- Treat geographically dispersed resources though they were centralised
- Link parallel activities instead of integrating their results
- Put the decision point where the work is performed and build control into the process
- Capture information once and at source

Edosomwan (1996)

- Consistency of Purpose
- Simplifying Structures /Processes/ Procedures / Policies / Systems/ Programs
- Eliminate/minimise Waste
- Design/implement Parallel Processes
- Focus on Constant Innovations & the use of Technology
- Create & Implement Performance based Measures to assess process outcomes
- Implement error and defect prevention philosophy at all levels
- Define process owners, stakeholders, suppliers
- Involve customers, process owners, suppliers re-engineering effort
- Promote radical & incremental improvements
- Eliminate/minimise the number of task elements within a given process
- Maximise the use of all resources available
- Combine/re-arrange the sequences of processes
- Substitute/simplify methods of performing a given task
- Change the sequence of performing a task
- Use new technology or tool to replace the method of performing a given task

Harrington (1991)

- Bureaucracy Elimination
- Duplication Elimination
- Value Added Assessment
- Simplification
- Process Cycle Time Reduction
- Error Proofing
- Upgrading
- Simple Language
- Standardisation
- Supplier Partnerships
- Big Picture Improvement
- Automation/mechanisation/computerisaton/IT

Jain et al (1993)

- Relocation of activity to initiator
- Relocation of activity to receiver
- Aggregation of successive activities
- Aggregation of successive task and decision activities
- Make concurrent activities that have work objects in common
- Introduce a master co-ordinator to connect task and decision activities

Guha, Kettinger, Teng (1993)

- Identify undesirable sequential activities and unnecessary bureaucratic steps
- Identify functional information systems that can be integrated into a single process wide system
- Question the need for various forms, approvals, reports and identifying all paper floats and redundancies
- Identifying dysfunctional policies and rules , formal as well as informal (Pattern Breaking)
- Eliminate of hierarchies. Replace hierarchies with self managed teams
- Can roles used simply to relay information be handled instead by information systems
- Task compression and integration
- Use IT to support/improve the re-design process

Davenport (1993)

- Information technology as an enabler Automational, Informational, Sequential, Tracking, Analytical, geographical, Integrative, Intellectual, Disintermediating
- Structure process performance by teams
- Job quality

5.2 Characteristics of the Process Improvement Actions

There are many re-design principles, guidelines and process changes suggested throughout the re-engineering and business process re-design literature, however these are not all included as Process Improvement Actions within this research. A Process Improvement Action should have the following characteristics:

- Result in a change to one or more of the process components
- Applicable at process and/or activity level
- Result in process improvements directly, not through further actions
- Concerned with the configuration of the 'Make Product' process undertaken during process re-design not with the management and operation of that process

For example, using the above definition, extended enterprise concepts as suggested by Harrison and Pratt (1993) are strategic concepts, not actual actions and are not applicable at process or activity level. Combining several jobs into one (Hammer and Champy, 1993) is an action that can be applied to the activities within a process and should result in a performance improvement, so is allowed.

5.3 Description of the Process Improvement Actions

This section describes the Process Improvement Actions taken from Figure 5.1. These Process Improvement Actions were generated as a result of an initial grouping of common titles into Process Improvement Actions and disregarding suggestions that were not considered to have the required characteristics of a Process Improvement Action.

Move activity to initiator

This is an action suggested by Jain et al (1994) referring to the movement of an activity currently performed by the internal operations out from the organisation to the person or organisation who initiated the work. This is applied to the final activity. If this is not viable then it is applied to the penultimate activity and so on. It is first applied to decision activities and then to task activities. Jain et al (1994) offer, as examples, automatic teller machines, otherwise known as cash points and outsourcing of logistics where a manufacturer may ship direct to a customer on behalf of the seller.

Error Proofing

Harrington (1991) believes that there are many opportunities to make errors and mistakes and that processes and activities should be designed so that it is difficult or impossible to create errors. Edosomwan (1996) also suggests the use of error proofing within processes.

Reduce unnecessary bureaucracy, rules, checks and controls

Harrington (1991) believes that unnecessary checks, approvals, procedures etc. that have no obvious role elsewhere within the process or organisation should be eliminated from the process. They are obstacles to the efficiency and effectiveness of the process.

Hammer and Champy (1993) agree stating that checks and controls should only be used '*...to the extent that they make economic sense.*' Any more are non-value-adding and should be eliminated. Ballé (1995) and Guha et al (1993) also believe that too many checks, controls and dysfunctional policies and rules detract from the efficiency and effectiveness of a process and should be eliminated. Ould (1995) agrees that all authorisations and approvals should be reviewed, but suggests strengthening them is a possibility, as an alternative to relaxing or eliminating them.

Case managers, workers and teams

Hammer and Champy (1993) introduce the concept of a case manager. A case manager acts as an interface with the customer. They are used where a process is complex and though they do not perform the whole of the process they have access to all of the people and information regarding the process that they require to answer any questions the customer may have. Ballé (1995) suggests that where several activities or tasks within a process are integrated into one a caseworker or team can look after the complete process. If it is not possible to integrate all of the tasks then the caseworker or team will be responsible for managing any interfaces within the process. The caseworker also acts as a single point of contact for the customer regarding the process. Armistead et al (1995) and Ould (1995) also discuss the use of a caseworker.

Jain at al (1994) suggest that there should be a master co-ordinator who plans and co-ordinates the activities within a process. The master co-ordinator, who should understand the process and have access to all of the process information, can make decisions regarding the running and configuration of the process.

Organise around outcomes, not tasks

Hammer (1990) states that a process should be organised on the basis of its outcome and not around the tasks within it. The aim of this is to have one person perform all of the activities within a process with their jobs designed around the process outcome not an individual task. Ould (1995) expresses this in terms of a single individual carrying out several roles or activities. Armistead et al (1995) bring an operations perspective to process re-design equating the suggestion to the design of operational processes to meet the requirements of the customer. Harrington and Harrington (1995) refer to the 'Theory of Ones' which is essentially the same as organising around outcomes. It should be decided what a process should do to transform the process input into an output required by the customer and then considered whether the process can be achieved in one activity and by one person.

Minimise tasks and hand-offs

Hammer and Champy (1993) suggest that as few people as is possible should undertake a process. A single person performing the whole process should be aimed for though this may not be possible. Ballé (1995) concurs believing that there are often too many hand-offs in processes that cause inefficiencies and problems within the process, as does Edosomwan (1996) who suggests that the number of tasks within an operation should be reduced.

Combine/integrate tasks

Several distinct tasks can be compressed into one (Hammer and Champy, 1993). This may include several specialist jobs being combined into a single position. The person in this position may be responsible for the whole process and would be a caseworker. If compression into one position is not possible a case team may be established. Guha et al (1993) also suggest that separate tasks should be integrated into as few job roles as possible, ideally one. Edosomwan (1996) also refers to the number of task elements within an actual activity stating that these should be eliminated or minimised.

Jain et al (1994) suggest two ways of combining activities. The first of these is the aggregation of successive activities of the same type i.e. task or decision into one activity. This may involve the automation of several activities or a generalist performing successive activities each of which was formerly performed by a specialist. The second suggestion is to aggregate successive task and decision activities providing they both work on the same item. Where as previously the person performing the task would have handed over to someone else to make the appropriate decision they now perform the activity and the associated decision.

Perform activities in parallel

Processes should be rearranged with activities performed in parallel (Edosomwan 1996). Ballé (1995) and Jain et al (1994) agree stating that if activities within a process are non-dependent they can be performed in parallel. In fact this process improvement action appears frequently throughout the literature and is also suggested by Harrison and Pratt (1993), Guha et al (1993), Davenport (1993), Watson (1994) and Harrington (1991).

When activities are performed by separate parts of an organisation and then brought together problems can be encountered when integrating (Hammer, 1990). These parallel activities should be linked and co-ordinated whilst they are being performed not only once they come together. Armistead et al (1995) and Ould (1995) also suggest this.

Perform activities in a natural order

Hammer and Champy (1993) suggest that the activities within a process should be performed in a natural order rather than the linear order often applied. They should be sequenced in terms of need and what must follow. In this way many activities can be performed simultaneously. Armistead et al (1995) also suggest linking activities in a natural order but do not expand on this merely suggesting the use of techniques such as simultaneous engineering.

Elimination of non-value-adding activities

Harrington (1991) classifies activities as real-value-added (add value for customer), business-value-added (add value for business) and no-value-added (no value whatsoever).

Activities, especially those that do not add value can be eliminated if doing so does not degrade the product or service or the business. Edosomwan (1996), Ballé (1995), Watson (1994) and Guha et al (1993) also suggest that companies should identify their value-adding and non-value-adding activities and eliminate those that do not add value.

Eliminate tasks

Several authors (Harrington 1991, Harrison and Pratt 1993, Ould 1995 and Ballé, 1995) all suggest the elimination of tasks for various reasons such as duplication or redundancy.

Simplification

Complexity should be reduced wherever possible (Harrington, 1991). This simplification includes changes encompassed in many of the other Process Improvement Actions such as the elimination of bureaucracy, having fewer stages, combining and eliminating activities, changing the sequence of activities and elimination of non-value-adding activities. Harrison and Pratt (1993) and Edosomwan (1996) make the same suggestion.

Simplification can, according to Harrington (1991), also include such things as the simplification of the verbal and written language used and the standardisation of documentation and procedures, so that all employees perform processes in the same way.

Standardisation

Harrington (1991) suggests that all procedures and documentation regarding a process should outline the best method of performing a task or process and be standardised so that everyone can understand them.

Those who use the output of a process should perform the process

Many organisations have specialised departments to perform specific tasks, such as purchasing (Hammer, 1990). These specialised tasks can be brought back into the process itself often through the use of information technology. This concept can be extended to organisations moving some of the activities within a process to the customer. For example a customer requiring a product repair can undertake simple repairs themselves once they have spoken to a diagnostic expert, possibly using a decision support system at the product manufacturer.

Jain et al (1994) suggest that activities performed by the internal operations of a company can be moved to the recipients of the product or service provided. If there are several recipients then it can be applied to them all.

Harrison and Pratt (1993) refer to the displacement of specialist functions. This can be achieved by moving work from the specialist function back into the process. The work may also be moved outside the organisation in the case of quality assured inputs. Ould (1995) agrees that now information can be made readily available to everyone so where an activity was previously performed outside the process it can now be performed in the process.

Armistead et al (1995) take an operational perspective promoting partnerships between different parts of the process and stressing that the process should be the most important focus.

Work where it makes the most sense

Hammer and Champy (1993) suggest that work should be performed where it makes the most sense. The description that they offer for this principle is actually the same as that offered by Hammer (1990) when he suggested that the people who use the outcome of a process should perform it. However it also includes the concept of the organisation moving some of its activities back to the suppliers of the process, for example a car manufacturer having a tyre supplier manage the inventory and delivery of tyres required for fitting on the vehicles.

Ballé (1995) also discusses the concept of working where it makes the most sense, comparing the relative merits of a specialised purchasing department and the people in the processes undertaking purchasing activities themselves.

Armistead et al (1995) also suggest that work should be performed where it makes the most sense, particularly checks, controls, information processing and decision making. They suggest for example that final inspection is moved from the end of the process and replaced by inspection at source by the operators. The gist of the action is that control, inspection and decision type activities should be performed as part of the process, in the appropriate place rather than at the end of the process or remote from the process. Such checking and decision making activities may or may not be supported by information technology.

Make information part of the process

Hammer (1990) states that information processing should be undertaken as part of the process that produces the information rather than a separate information processing unit. Ould (1995) again expresses this in terms of roles, questioning if separate roles used to produce and process information could be integrated.

Put the decision point where the work is performed

Hammer (1990) suggests that a decision point should be put where the activity to which it applies occurs and that control should be built into the process. The people doing the work should make the checks and decisions required at the appropriate point in the process, as opposed to inspectors, managers and supervisors etc. performing the checks remotely. Ould (1995) expresses this in terms of roles as the movement of management decision and checking roles into the main process.

Workers make decisions

Hammer and Champy (1993) suggest that the people within the process should make their own decisions rather than having to go to managers or supervisors for answers. Decision-making becomes part of the work rather than being a separate decision-making activity. Ballé (1995) agrees that decision-making should be delegated to the workplace, thus decisions will be made by the employees working on the process and in real time.

Have multiple, appropriate processes

Hammer and Champy (1993) suggest that there should be multiple processes or processes that split into multiple paths following an initial triage activity. Processes that are standardised so that they can cope with the requirements of many customers or product versions are complex. Multiple processes or paths should be developed that are specialised to the requirements of their particular market or product. Ould (1995) agrees, stating that following an initial triage activity, different routes through the process can be chosen depending on the work been processed.

Ballé (1995) believes that processes that have been built to deal with both simple and complex cases, often result in simple jobs queuing up behind complex jobs. Processes should therefore be split into separate process paths to deal with the possible alternatives. These alternative routes may be fully automated, performed by a generalist with an expert system for guidance or in the most complex cases performed by a specialist. Armistead et al (1995) state that multiple versions of processes should be developed where appropriate. In the case of manufacturing processes they should be matched to the product complexity and volume, resulting in multiple processes rather then a single general process.

Change sequence

Edosomwan (1996) suggests that the sequence of a process can be re-arranged to improve the performance of the process and that the most efficient sequence and method of transportation should be adopted. Harrington (1991) also suggests the re-sequencing of activities, with specific regard to reducing travel within the process.

Integrate separate information systems

Guha et al (1993) stated that function- or department-based information systems should be integrated into one process wide system.

Capture information once, at source

Hammer (1990) states that information should be collected once, at source. It can then be used by all who need it. This can be achieved through the integration of functional information systems. Ballé (1995) suggests that re-entry of data should be eliminated and data collection automated where possible. Armistead et al (1995) agree that there is no longer a need for re-entry of data as modern technology has allowed the same data to be used throughout a process. Hammer and Champy (1993) concur that due to technology, information can be made available to many people simultaneously, which allows for parallel processing of data, thus information needs to be collected only once. Hammer and Champy (1993) refer to re-entry of data as 'terminal disease'. They stress that this need not only involve information held in computers but general communication.

Reconciliation is minimised

Hammer and Champy (1993) suggest that the number of contact points between the process and the world around it be minimised. This reduces the possibility of collecting inconsistent data that requires reconciliation.

Centralise geographically dispersed resources

Information technology enables organisations to operate in autonomous units whilst still reaping the benefits of economies of scale (Hammer and Champy 1993). Hammer (1990) also states that information technology can be used to reap the benefits of both central and decentralisation describing it as an ability to centralise geographically dispersed resources. Armistead et al (1995) also believe that this linking between geographically dispersed resources is important especially within service operations.

Generalists can do the work of specialists

The use of databases and expert systems has allowed relatively unskilled people to operate in a way equivalent to that of a trained specialist (Hammer and Champy, 1993).

Team working

Guha et al (1993) state that hierarchies within an organisation should be replaced with self-managed teams. Davenport (1993) also advocates the structuring of process performance by teams.

Empowerment

As the responsibility of teams increases due to the changes implemented so they must be given more authority to make decisions (Ballé, 1995).

Restructure roles

Ould (1995) suggests that roles can be restructured, for example any member of a management board could approve a large capital expenditure given the required information, the decision does not have to be made by the Managing Director.

The use of information technology to support/enable the process

Harrington (1991) and Edosomwan (1996) suggest that new equipment or technology can be used to improve a process. Harrington (1991) also suggests that automation can be used to improve the operations of a process.

Hammer and Champy (1993) discuss the enabling role of information technology in business re-engineering and how it can be used to break some of the traditional rules of organisations. Essentially information technology and the sharing of information can be used to enable many of the Process Improvement Actions discussed within this chapter.

Davenport (1993) summarises the enabling potential of information technology as:

- Automational - Eliminating humans from the process
- Informational - Capturing process information
- Sequential - Changing process sequence or enabling parallel processing
- Tracking - Monitoring processes and objects
- Analysis - Improving decision making
- Geographical - Co-ordinating across distances
- Integrative - Co-ordinating tasks and processes
- Intellectual - Capturing and distributing intellectual assets
- Disintermediating - Elimination of intermediaries

As with Hammer and Champy (1993) the potential of information technology can be used to enable many of the Process Improvement Actions discussed within this chapter. Ballé (1995) and Guha et al (1993) also advocate the use of technology and information technology to enable process improvements.

5.4 Generic Process Improvement Actions and their definitions

The descriptions of the Process Improvement Actions detailed in section 5.3 illustrate the fact that different authors describe the same change in different ways or under different titles. When describing these Process Improvement Actions it became apparent that several of them were actually suggesting the same process improvement. For example Organising around outcomes, Minimising hand-offs and Combing and integrating tasks are actually all making the same change to the process. These therefore became a generic Process Improvement Action.

The generic Process Improvement Actions that emerged from the descriptions of the many Process Improvement Actions in section 5.3 are defined in this section. These Process Improvement Actions and definitions form the basis of those used in the preliminary questionnaire described in Chapter 7 and will be refined as a result of the preliminary questionnaire findings.

1. Reduce the number of activities within a process

The number of separate activities that are required to complete a process should be reduced to the minimum possible. This will reduce the interfaces and hand-offs within the process. This may involve the integration of activities that already exist within the process.

2. Introduce a case manager, worker or team

Where the activities within a process have been integrated and minimised an individual or a team can be used to perform the process and manage any remaining interfaces and hand-offs. This person or team can be referred to as a caseworker or case team. Where a process remains too complex to be performed by one person or team then a case manager can be appointed. A case manager has an overall picture of the process and access to all information regarding the process. They act as a single point of contact with the customer regarding the process.

3. Perform activities in parallel rather than sequentially

Activities within a process that are not dependent upon each other can be performed in parallel or concurrently. For example, the manufacture of two sub-components that are to be assembled into a final product need not be performed sequentially, but in parallel. Work may also be conducted concurrently by separate parts of an organisation and then integrated together as in the case of concurrent engineering. In either of these cases, though the parallel or concurrent activities are performed independently, there must be co-ordination and communication between them during processing and not just when integrated.

4. Eliminate non-value-adding activities

Activities that are redundant, duplicated, outdated or driven by bureaucracy do not add value to a process. These activities should be analysed to identify whether they have any real value within a process, or another process within the organisation, if not they should be eliminated.

5. Standardise

Procedures and process documentation should be standardised so that everyone performs a process in the same way.

6. Simplify language

The verbal and written communication within the process can be simplified.

7. Error Proof

Processes are designed or re-designed in such a way that it is impossible to make mistakes.

8. Move activities into the process

This Process Improvement Action involves the movement of activities to the most sensible point in the process for them to be performed. This can be achieved in several ways. Activities that are performed externally to the process can be moved back into the appropriate point within the process. Activities that are performed outside the process on behalf of the process such as information processing, purchasing and checking should be moved back into the appropriate place within the process. Information technology may or may not be used to support these changes.

9. Move activities out of the process

This Process Improvement Action involves the movement of activities that are performed by the process out of the process. This can be to another process within the company or to someone external to the organisation. Activities can be moved to suppliers and customers.

Move an activity performed by the process to a supplier. For example, goods in inspection can be moved to the supplier by insisting on quality assured inputs that can be used by the process without inspection. The supplier therefore becomes responsible for the inspection operation.

Move an activity performed by the process to the customer. The product or service therefore leaves the process in a different state from previously. For example flat packed furniture or the customer performs the whole process such as with cash points.

In either case suppliers or customers may be internal or external.

10. Make the people or teams performing the activities responsible for the activity

If an activity is moved back into a process from a remote function as in 8, then the work involved in completing that activity becomes the responsibility of the people within the process. This requires, particularly in the case of control and checking type activities that the people within the process are given greater responsibility to make decisions.

Processes can be performed by self-managed teams rather than through hierarchical management structures. This also requires that the people working within the teams have greater responsibility than they had previously.

The increased responsibility given to those performing the process, be it as individuals or as teams, requires that they be empowered with the authority required to undertake their new roles.

11. Introduce multiple routes or paths through a process

Alternative routes or paths could be created so that complex and simple work are put through separate processes or separate process paths after an initial triage.

12. Re-sequence activities

The sequence in which activities are performed can be changed. These activities may, or may not be geographically dispersed.

13. Use Information Technology (or Technology) to enable activities and processes

This Process Improvement Action refers to the implementation of technology or information technology in an activity or process. For example if an activity is performed by a human, the human can be replaced and the activity performed by a machine.

Information technology or technology can also be used merely to support another Process Improvement Action. For example the use of shared information databases by separate areas performing concurrent activities.

5.5 Conclusion

It would appear that there is a proliferation of suggestions regarding the change, improvement and re-design of processes throughout the literature. It is possible to distil them into a generic set. This is because several authors make many of the suggestions, though they may use different terms to describe them. Also many of the suggestions are not actionable changes that can be made to processes or activities and therefore are not classified as Process Improvement Actions in this research. The outcome of this chapter is a set of generic Process Improvement Actions and their descriptions. These generic actions and descriptions will, in later chapters, be linked to the performance improvements gained through their implementation.

Chapter 6 - Performance Requirements

This chapter explains the selection of the performance measurement criteria, dimensions and measures that are used within this research. To aid this selection a set of characteristics for assessing the applicability of performance dimensions and measures to this research are stated. Performance dimensions and measures that satisfied these applicability characteristics were then selected from those suggested throughout performance measurement literature. The resulting list of Performance Requirements presented does not constitute an exhaustive list but rather represents some of the most common Performance Requirements applicable.

6.1 Characteristics of the performance measurement criteria

There are many performance dimensions and performance measures suggested throughout the literature. This research does not attempt to identify all possible performance dimensions and measures but only those appropriate for the scope of the research as outlined in Chapter 2.

When developing performance measures it is important to consider the process for which they are being developed and the level of organisation to which they are applicable. For example the performance measures suitable for the 'Product Introduction' process will be different from those for the 'Fulfil Order' process. Also the measures used by the management team of an organisation will be different from those used by the people on the shop floor.

The Performance Requirements placed on the 'Make Product' process should be ones where the changes made to that process alone contribute to performance; several processes will influence some Performance Requirements. Where this is the case the Performance

Requirement applied to the 'Make Product' should be a component of the overall Performance Requirement, for example the contribution of 'Make Product' to despatch reliability is through the improvement of lead-time performance.

The performance dimensions and measures selected for use as variables within the questionnaire were therefore:

- Within the scope of the research i.e. applicable to the 'Make Product' process
- Meaningful at the level of the 'Make Product' process i.e. operational rather than strategic
- Ones where the changes made to the 'Make Product' process alone contribute to performance.

6.2 Derivation of performance dimensions and requirements

There are many texts available within the field of performance measurement. The performance measurement dimensions and measures were gathered from a sample of these. Different authors suggest different dimensions of performance measurement and often express the same dimensions in different ways. This depends on the level of the organisation they are considering such as the strategic top-level or the process level. Some authors include both top-level and process-level dimensions and measures within their set.

Sections 6.2.1 and 6.2.2 discuss the derivation of the performance dimensions and measures appropriate for this research.

6.2.1 The performance dimensions

Analysis of the literature indicated that the dimensions of cost, quality, time and flexibility encompassed the most frequently mentioned performance dimensions that could be applied to the 'Make Product' process. Neely et al (1995) similarly use time, cost, quality and flexibility when categorising performance measures for a manufacturing company.

Table 6.1 lists the other authors who suggest time, cost, quality or flexibility as performance dimensions and the terms with which they refer to them.

Performance Dimension	Other terms used	References
Time	Speed, Process Time, Cycle Time, Lead Time, Dependability	Slack et al (1995), Cox et al (1992), Lynch and Cross (1995) Laasko and Bredrup (1995), DeToni and Tonchia (1996) White (1996), Medori (1998), Wisner and Fawcett (1991), Hayes et al (1988) Maskell (1989)
Cost	Price	Wisner and Fawcett (1991), Hayes et al (1988), Richardson and Gordon (1980), Slack et al (1995), Maskell (1989). Cox et al (1992), Laasko and Bredrup (1995), DeToni and Tonchia (1996), Azzone et al (1991), White (1996), Medori (1998)
Quality	Referred to as quality by all authors	Hayes et al (1988), Slack et al (1995), Medori (1998), Wisner and Fawcett (1991), Maskell (1989), Richardson and Gordon (1980), Cox et al (1992), Lynch and Cross (1995), Laasko and Bredrup (1995), DeToni et al (1996), Azzone et al (1991), White (1996)
Flexibility	Product/Process Flexibility, Flexibility of Resources	Hayes et al (1988), Wisner and Fawcett (1991), Cox et al (1992), Azzone et al (1991), White (1996), Medori (1998), Slack et al (1995), Richardson and Gordon (1980), Maskell (1989), Lynch and Cross (1995)

Table 6.1 – The four performance dimensions

There are other performance dimensions suggested throughout the literature that have not being included in this research either because they were only included in one or two lists or because they do not fit within the scope of the research. The three most commonly suggested were:

Dependability

Hayes et al (1988), Wisner and Fawcett (1991) and Slack at al (1995) suggest dependability as a dimension of performance. Slack defines dependability as *'doing things in time for customers to receive their goods or services when they were promised.'* The measures suggested by Hayes et al (1988), Wisner and Fawcett (1991) and Slack et al (1995) include measures such as lead-time reduction, delivery promises met and warranty turnaround times. Therefore dependability has not been included as a separate dimension but is incorporated in the time dimension.

Delivery

Maskell (1989), Richardson and Gordon (1980), Lynch and Cross (1995), White (1996) and Medori (1998) suggest delivery amongst their performance dimensions. Cox et al (1992) refer to it as due date conformance but add delivery in brackets and Azzone et al (1991) refer to timeliness of product. Whilst delivery can be applied to the output of the 'Make Product' process it is affected by factors outside of the process, such as purchasing and decisions regarding promised delivery dates.

Innovation

According to Hayes et al (1988), Wisner and Fawcett (1991), Cox et al (1992) and Kaplan and Norton (1992), innovation is a dimension of performance. Innovation measures can be applied across the whole of the organisation and to the make product process. Innovation in the make product process could be achieved through innovative methods of undertaking the specific tasks required making a product. The application of any of the Process Improvement Actions described within this research could be considered innovative.

6.2.2 The Performance Requirements

The performance measurement literature does not discuss the specific performance measures to adopt to the extent it discusses performance dimensions. Writers tend to discuss methods and frameworks for developing measures or suggest measures applicable to certain circumstances or dimensions. Medori (1998) and White (1996), however, produced comprehensive lists of performance measures suitable to manufacturing companies.

Medori (1998) developed a performance measurement checklist suggesting performance measurements suitable for 'world class' manufacturing companies. These are listed under the competitive priorities of quality and customer satisfaction, cost, flexibility, time, delivery and future growth. Again at a process-level these can be considered to match the generic dimensions of time, cost, quality and flexibility. Future growth is a top-level priority, delivery can be considered in terms of time or quality and quality and customer satisfaction can be expressed at process-level in terms of time, cost, quality or flexibility dependant on customer requirements.

White (1996) developed a taxonomy of strategy-related performance measures for manufacturing. These are categorised under the dimensions of cost, quality, flexibility, delivery and speed. At process level these match the generic dimensions of time, cost, quality and flexibility. Speed is equated to the time dimension and delivery can be considered in terms of time or quality.

When considering the performance measures suggested by Medori (1998) and the measurements suggested in the taxonomy of White (1996) under the four performance dimensions of time, cost, quality and flexibility the common measurements satisfying the characteristics outlined in section 6.1 were drawn out. These are listed under each of the generic criteria of time, cost, quality and flexibility and are shown in Table 6.2. The performance measures placed on a process can be used for process re-design to establish the Performance Requirements. For example if Rework time is the measure the requirement is to Reduce Rework time.

Time	Cost	Quality	Flexibility
Manufacturing Lead-time Cycle Time Lead-time Reliability Rework Time Set-up Time Inspection Time Distance Travelled Machine Down-time Output Rate	Labour Productivity Machine Productivity Cost of Rework Cost of Scrap Cost of Labour Cost of Inventory Cost of Material Cost of Inspection Cost of Work in Progress Total Operational Cost Labour Efficiency Machine Efficiency	Quantity of Rework Quantity of Scrap Yield Defects per Batch Rework Labour Number of Inspection Activities Non-Conforming Product	Lead-time to Make Product Range of Products Predictable Output when Conditions Change Changeover Time Bottlenecks

Table 6.2 - The Performance Requirements

6.2.2.1 Definitions of the Performance Requirements

To ensure a common understanding of the Performance Requirements to be used within this research, definitions of each are included within this section. These were based on those of Medori (1998) but the wording was adapted to ensure that they were meaningful for this research. These Performance Requirements and definitions form the basis of those used in the preliminary questionnaire described in Chapter 7 and are refined as a result of the preliminary questionnaire findings

Manufacturing lead-time

The manufacturing lead-time is the time that it takes to manufacture a product from the point that the work starts to the time that the product is completed.

Cycle time

The cycle time encompasses the time taken to manufacture a product including the processing, moving, waiting, inspection and set-up time.

Lead time reliability

The reliability of the lead-time is a measure of how consistently the process can produce a product with the same lead-time.

Rework

Rework includes the operations and activities that have to be repeated because the work resulted in defective outcome the first time. This can be measured in terms of the time to rework, the cost of rework or the general level of rework within the process.

Set-up time

Machinery, equipment and activities need to be set up in different ways for different work. Set-up time is the time it takes to do this.

Inspection

Inspection is conducted to ensure that work was completed correctly. This can be measured in terms of the time that the inspection takes, the number of inspection activities in the process or the cost of those activities.

Distance travelled

This is the physical distance that the work travels through the process whilst being worked on.

Machine down-time

This is the time that a machine or equipment is not available.

Output rate

This is the rate at which completed work is generated by the process.

Productivity

The productivity of people or of machines can be measured. It is a comparison of the amount of work completed and the actual time taken to undertake that work.

Scrap

Defective work produced by the process that cannot be reworked must be scrapped. This can be measured in terms of the cost or of the general level within the process.

Inventory

Inventory includes the raw material, work in progress and finished goods within the process. It is measured in terms of cost.

Material

Manufacturing processes convert raw material into finished goods or scrap. This is the cost of the material consumed.

Work in progress

Work in progress includes work that has started within the process, but is not yet complete. It is measured in monetary terms.

Total operational cost

This is the total cost required to operate the process including machine and labour costs.

Efficiency

The efficiency of people or machines can be measured. It is a comparison of the actual hours to complete some work and the standard allowed hours allowed to undertake that work.

Yield

The yield of the process is the proportion of the product that conforms to the specifications set for it. The inverse measure is the proportion of non-conforming product generated by the process. This is measured over a set period of time e.g. monthly yield

Defects per batch

When a batch of work is produced this considers how many of the batch are defective and do not comply with specification.

Range of products

A process may be capable of producing more than one product or product variant. This is a measure of how many.

Predictable output when conditions change

This is a measure of how predictable the output of a process is when the requirements placed on the process change, such as the volume or mix of product to be produced.

Changeover time

This is the time that it takes to change the process from manufacturing one product to another product or variation of product.

Bottlenecks

The number of activities within a process at which queues occur and work is held up due to lack of capacity.

6.3 Conclusion

This chapter resulted in a list of Performance Requirements, categorised under the dimensions of time, cost, quality of flexibility. To aid in the selection of performance dimensions and measures appropriate to the 'Make Product' process and within the scope of this research a set of characteristics was developed. Performance dimensions and measures that met these characteristics were then selected from those suggested in the performance measurement literature. The Performance Requirements were selected from the works of Medori (1998) and White (1996). Each of the selected performance measures was then briefly defined. The list of Performance Requirements will, in later chapters, be linked to the generic Performance Improvement Actions derived in Chapter 5.

Chapter 7 - Questionnaire design

In Chapters 5 and 6 the Process Improvement Actions and Performance Requirements applicable to the 'Make Product' process were derived from the business process re-design and performance measurement literature. These Process Improvement Actions and Performance Requirements constitute the variables to be included in the questionnaire.

The questionnaire that was developed to investigate the relationships between the variables is outlined in this chapter. It entailed three stages of design including two of testing, the preliminary and the pilot stages. This thorough approach was necessary to ensure the validity and reliability of the questionnaire.

The survey sample to which the final survey was administered is discussed in terms of the sampling method, survey size, pureness and possible bias. Possible non-response error is also dealt with.

7.1 Questionnaire design method

The questionnaire used within this research was subject to several stages of design and testing, as shown in Figure 7.1, before the final version was considered ready for use and distribution. This approach enabled the number of variables and thus questions to be pared down to a workable number and most importantly improved the validity and reliability of the questionnaire and hence the credibility of the results. The actions taken to improve the validity and reliability of the questionnaire are discussed in detail at the end of this chapter.

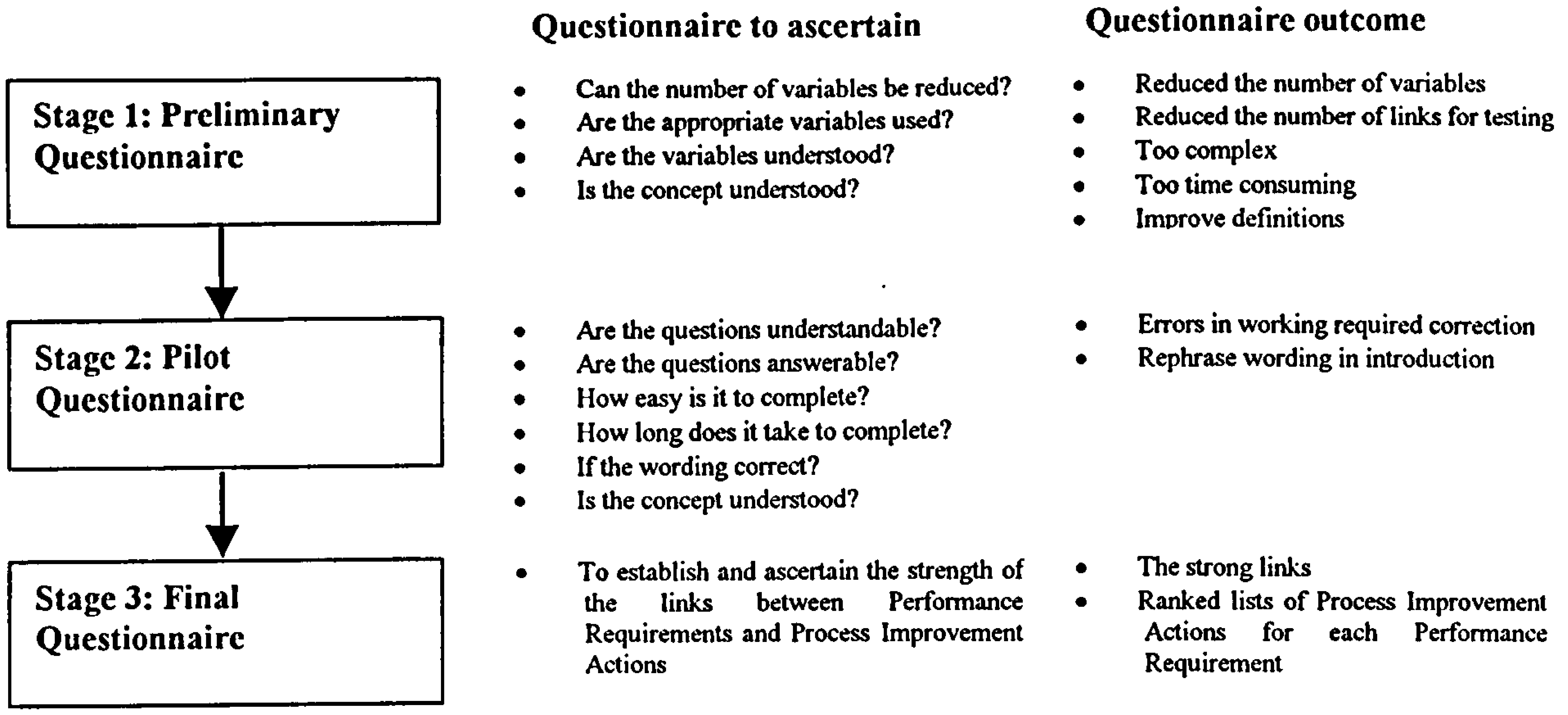


Figure 7.1 – The stages of questionnaire design

7.2 Preliminary questionnaire

7.2.1 Design of the preliminary questionnaire

The aim of the questionnaire used within this research was to ascertain the strength of possible relationships between Performance Requirements and the Process Improvement Actions implemented to achieve them. The preliminary questionnaire was designed to establish where relationships existed and to reduce the number of variables for consideration, so that later versions of the questionnaire would be shorter and easier for respondents to complete. The preliminary questionnaire also tested whether the overall concept was understood, whether the appropriate variables were being investigated and whether the respondents understood these. A copy of the preliminary questionnaire can be found in Appendix 3.

The structure of the preliminary questionnaire was simple. It was presented as a matrix of the fourteen Process Improvement Actions (*Move activities out of the process to the customer or the supplier* was included as two separate variables) against the thirty-three Performance Requirements identified in Chapters 5 and 6 respectively. The questionnaire was accompanied by definitions of each of the variables.

The preliminary questionnaire was completed row by row, with respondents ticking each of the Process Improvement Actions that they thought would improve each individual Performance Requirement. For example, for the Performance Requirement of Manufacturing lead-time they should tick the Process Improvement Actions that would reduce the Manufacturing lead-time.

7.2.2 Survey sample for preliminary questionnaire

The preliminary questionnaire was completed by a sample of thirteen people. The sample included 5 academics whose specialist areas included business process re-engineering, re-design and continuous improvement (2), manufacturing systems (1), quality (1), and performance measurement (1). 3 of them had previously worked as manufacturing/production engineers within manufacturing companies and all were actively involved in improvement projects within local companies.

The remainder of the sample (8) were practitioners working in the electronics sector (1), defence (1), motor manufacture (1), electronic enclosure manufacture (1), yacht manufacture (1) construction equipment manufacture (1) and unspecified manufacturing (2).

With regard to the size of company of which the practitioners had experience, 2 were working in large companies and the other 6 in SMEs as manufacturing/production engineers or process improvement specialists.

This group was deemed to have the required knowledge to complete and comment on the questionnaire in such a way that the comments could be used to influence the design of the full questionnaire.

7.2.3 Analysis of the preliminary questionnaire

Analysis of the completed preliminary questionnaires took two forms, general consideration of how people understood and completed the questionnaire and some statistical analysis of the results collected.

General observations

Whilst the matrix structure of the questionnaire was a simple way for the researcher to present the variables and gather the information required, it turned out not to be simple for those completing the questionnaire. They found it complex and time consuming to complete and the accompanying definitions, whilst they helped, required further detail in some areas.

Statistical conclusions

The initial matrix questionnaire consisted of thirty-three Performance Requirements and fourteen Process Improvement Actions. Some consideration was required as to how to reduce the size on the basis of the thirteen preliminary questionnaires completed. As the respondents were allowed to tick as many links as they thought appropriate this led to problems in the statistical analysis of the results. When a Chi Squared test was attempted it was not possible to obtain the level of 'expected' values required to complete the analysis. However, since the questionnaire was completed line by line with each performance measure being treated independently there was actually no need to analyse the questionnaire as a whole, line by line was considered appropriate. The aim was to limit the size of the questionnaire by determining the strongest links and presenting these for further investigation in another questionnaire.

To ascertain these significant links the mean number of ticks for each Performance Requirement was calculated and any of the Performance Requirement to Process Improvement Action links that had more than the mean number of ticks were considered significant in relation to the others for that Performance Requirement. Figure 7.2 shows an illustrative example of the calculations.

	PIA1	PIA2	PIA3	PIA4	PIA5	TOTAL	MEAN
Performance Requirement	5	6	1	7	9	28	5.6

Figure 7.2 – Ascertaining the significant links

This resulted in four or five Process Improvement Actions for each of the Performance Requirements that could be taken forward into the pilot questionnaire.

7.3 Pilot questionnaire

7.3.1 Design of the pilot questionnaire

This second questionnaire took the significant links established in the preliminary questionnaire and presented them as positive statements in the form *'To reduce Manufacturing lead-time……eliminate non-value-adding activities'* with a Likert scale accompanying each of them. This scale was ranked from strong effect (5) to no effect (1). A copy of this questionnaire can be found in Appendix 4.

The Process Improvement Action to *Simplify language* did not figure in any of the significant links established in the preliminary questionnaire, so was omitted from the pilot questionnaire. Therefore thirteen Process Improvement Actions were included in the pilot questionnaire. These Process Improvement Actions are also used in the final questionnaire and are listed in section 8.1.

The definitions for Process Improvement Actions and Performance Requirements were also updated to provide the further explanation called for in the pilot testing. These were also distributed for comment.

7.3.2 Survey sample for pilot questionnaire

This questionnaire was completed by a sample of nine people. These consisted of 6 colleagues whose specialist areas included business process re-engineering, re-design and continuous improvement (3), manufacturing systems (1), quality (1), and performance measurement (1). 4 of them had previously worked as manufacturing/production engineers within manufacturing companies and all were actively involved in improvement projects within local companies.

The sample also included 2 engineers responsible for undertaking improvements in a medium sized local company.

This group was deemed to have the required experience and knowledge to complete and comment on the questionnaire in such a way that the comments could be used to influence the design of the final questionnaire.

7.3.3 Analysis of the pilot questionnaire

Analysis of the pilot questionnaire entailed the collection of feedback from those who completed it in order to ascertain the ease of completion and approximate completion time, and to ensure that the questions were understood and could be answered by the respondent. Those completing the questionnaire found it a straightforward exercise though some of the respondents found answering some of the questions more taxing than others. Completion of the questionnaire took approximately thirty to forty minutes. No problems were encountered with the understanding of the questions though some errors were found in the wording of the questionnaire and introduction.

7.4 Final questionnaire

7.4.1 Design of the final questionnaire

The final questionnaire was essentially the same as the pilot questionnaire but incorporated changes as a result of the feedback received from testing and also included 'dummy links'. One of the recognised weaknesses within questionnaires is that respondents can tend to tick straight down a column without really giving sufficient consideration to the questions. To prevent this it is suggested that some of the questions be presented in a negative form (Sekaran, 1992). Unfortunately this did not make sense in the context of this questionnaire. The questionnaire was presented as sets of statements grouped under each Performance Requirement, for example *'To reduce Manufacturing lead-time……eliminate non-value-adding activities, perform activities in parallel'* etc. If the statement were to be phrased negatively as *'To increase Manufacturing lead-time….'* the meaning would be changed. Therefore to negate or check for the tendency to tick down columns, dummy process improvement links were included at random. These were in fact some of the weakest links identified in the preliminary questionnaire, so should really be ranked with no or little effect in this questionnaire.

At the end of the questionnaire there is a set of questions regarding the process re-design experience and background of the respondent. The purpose was to build up a profile of the respondent so that their eligibility for completing the survey could be checked. A copy of the final questionnaire can be found in Appendix 5.

7.4.1.1 The questionnaire scale

Likert scales are used extensively for the measurement of opinions (DeVellis, 1991). Since the requirement in this research was to gather opinions on the strength of effect of a Process Improvement Action on a Performance Requirement, the use of a Likert scale was appropriate. A five-point scale was adopted, as it was the most appropriate for the possible span of answers from 5 (Strong effect) through 4,3 and 2 to 1 (No effect).

When developing Likert scales for the measurement of attitude, particularly within social sciences, deciding the statements to be included is part of the scale development (Emory, 1985, Oppenheim, 1992). In this case the statements to be included had already been decided with the derivation of questionnaire variables and it was just the five-point scale that was adopted. According to Emory (1985) it is common and acceptable to develop Likert scales in an 'arbitrary' manner.

The effect of the scale on the statistical analysis

It is a matter of contention within statistical texts as to whether a Likert scale should be treated as an ordinal or an interval scale. It is however an important decision as the statistical analysis that can be undertaken is different for each of these scales. On an interval scale not only are responses ordered, in this case from 'strong effect' to 'no effect' but the difference between intervals between each pair of adjacent points on the scale are considered to be equal (Davis, 2000). On an ordinal scale the responses can only be ordered. It cannot be assumed that the differences between each point on the scale are all equal (Davis, 2000).

According to Wright (1997) many researchers in the social sciences would consider a Likert scale to be interval and assume that the differences between each of the points on the scale are equal. However Wright (1997) also believes that if they were questioned further they would agree that Likert scales do in fact only produce ordinal data.

It cannot be assumed that when completing the questionnaire the respondents considered the points on the scale from 'strong effect' to 'no effect' to be equally spaced. Nor can it be assumed that different respondents view the scale in the same way. One respondent may have a different perception of what constitutes a strong effect from another respondent (Fowler, 1993). The Likert scale used within this research was therefore treated as an ordinal scale.

As the results of a Likert scale can only be given an order and the distance between them is unknown the appropriate measure of average is the median or mode. Statistical significance should be established through the use of non-parametric statistics (Emory 1985, Siegel and Castellan 1988).

7.4.1.2 Questionnaire validity

The validity of a questionnaire is concerned with the degree to which it performs and measures as it is supposed to (Davis, 2000). There are three main types of validity applicable to survey based research; these are content, construct and criterion-related validity.

Content validity

Content validity is concerned with the degree to which the questionnaire contents represent the topic being studied (Emory 1985, Davis 2000). The survey contents should include the items required to represent and describe the concept that is being studied adequately, in this case process re-design and performance measurement. The contents should not include irrelevant items.

To ensure the content validity of a questionnaire there are four main actions that can be taken (Davis, 2000). These require the researcher to:

- Conduct an exhaustive literature review to ascertain the items to be included on the scale
- Solicit the opinion of experts on the addition/deletion of possible items
- Pre-test the scale on a set of respondents similar to the population to solicit suggestions regarding contents and wording
- Modify the questionnaire as necessary depending on the feedback obtained

These were all addressed in this research through the literature reviews and the preliminary and pilot questionnaires. The variables included in the questionnaire were derived from a thorough review of process re-design and performance measurement literature as outlined in Chapters 5 and 6 to ensure that the relevant variables were included. These variables were then incorporated into the preliminary questionnaire, the contents of which were considered by a group with knowledge in the areas under study, an action also recommended by Litwin (1995). Following the appropriate modifications the pilot questionnaire tested understanding, wording and content.

Construct validity

Construct validity is a measure of how well the scale being used represents and behaves like the concept being measured (Davis, 2000). Where relationships are hypothesised prior to application of the measurement instrument, construct validity is concerned with the degree to which the empirical results match those hypotheses (DeVellis, 1991).

Construct validity is particularly relevant where the phenomena being measured is not directly observable, for example motivation. Such phenomena are referred to as '*hypothetical constructs*' (Hussey and Hussey, 1997) and are often measured indirectly or inferred from summated scales comprising the operational definitions of the construct (Flynn et al, 1990). This questionnaire measures constructs and variables directly and not via inferred items. There is therefore less opportunity for the scale to measure constructs other than those that it was designed to measure. This adds to the validity.

Comparing how well the empirical results of the questionnaire match the results that could have been predicted assesses construct validity of the questionnaire, to some degree. In this case the links between Process Improvement Actions and Performance Requirements that are alluded to in process re-design literature can be considered as predicted results.

Criterion-related validity

Criterion-related validity is concerned with the extent to which the scale being used is able to predict the future level of a variable (Davis, 2000) and according to DeVellis (1991) is a '*....practical issue rather than a scientific one*'. It is concerned with predicting future results rather than understanding results.

Criterion-related validity has been criticised, as it is difficult to decide upon the criterion to use for validation purposes. Davis (2000) suggests that content and construct validity are of more importance that criterion-related validity. This is reflected by Malhotra and Grover (1998) who include the assessment of content and construct validity amongst the ideal survey attributes for Production and Operations Management research but do not discuss criterion-related validity. Criterion-related validity was therefore not implemented.

7.4.1.3 Questionnaire reliability

The reliability of the questionnaire is concerned with the '*....consistency and stability of a score from a measurement scale.*' (Davis, 2000) and thus how reproducible the results of the survey are. It considers the consistency of the questionnaire whereas validity was concerned with the accuracy of the questionnaire.

Reliability is primarily concerned with internal consistency, that is the degree to which homogeneous items on a measurement instrument will correlate with each other. Where there are strong correlations it can be claimed that the items are measuring the same thing. There are several methods of evaluating the internal consistency of a questionnaire. Cronbach's coefficient alpha is one of the most widely used and is the method used within this research for assessing the reliability of the questionnaire (Davis, 2000). Cronbach alpha scores were calculated for the four performance measurement dimensions of time, cost quality and flexibility.

The score obtained by a set of items on a scale will consist of true variation caused by the differing responses of those who completed the questionnaire and variation due to error. DeVellis (1991) refers to these as 'signal' variation and 'noise' variation respectively. Cronbach alpha splits the overall variance in a set of items into signal or noise variation and calculates the proportion of that variance that is due to signal variation. According to Davis

(2000) the minimum acceptable Cronbach score for exploratory research is 0.7, for basic research 0.8 and where decisions will be made on the grounds of the questionnaire results 0.9. This research is regarded as exploratory as described in Chapter 2.

Reliability of the final questionnaire

In order to establish the reliability of the questionnaire a Cronbach alpha score for internal consistency was calculated for each of the main categories of the questionnaire, time, cost, quality and flexibility. Since each of these asks a set of questions on a similar theme it can be expected that there would be internal consistency between them.

The Cronbach alpha scores calculated were 0.9016 for time, 0.9562 for cost, 0.9410 for quality and 0.9140 for flexibility all indicating good internal consistency.

7.4.2 Survey sample for final questionnaire

7.4.2.1 Sample selection

The aim of the questionnaire was to gather information on the strength of links between Process Improvement Actions and Performance Requirements. Therefore those completing the questionnaire required specialist knowledge and experience of process re-design or improvement within manufacturing companies.

Such requirements for particular expertise in an area are suited to judgement sampling with the sample being selected by the researcher. Whilst this results in a sample with the expertise required it could also result in a biased sample with very limited generalisability of results (Sekaran, 1992). To overcome this an alternative method of sampling was selected. Identifying the total population of process re-design experts was not considered feasible so in order to access some of that population it was decided to use specialist e-mail discussion groups to which they may subscribe.

The lists used were:

- *Business Process Management*

The ESRC Business Processes Resource Centre runs this list for multidisciplinary researchers and practitioners interested in BPR, IT, knowledge management, human factors, process improvement and strategic issues.

- *Complex Industries Special Interest Group*

The American Production and Inventory Control Society runs this list for professionals working with high technology products with low unit volume production.

- *Repetitive Manufacturing Special Interest Group*

The American Production and Inventory Control Society runs this list for professionals involved in process, assembly, or custom manufacturing in small to medium sized as well as high volume operations.

- *Small Manufacturing Special Interest Group*

The American Production and Inventory Control Society runs this for professionals in companies with less than $50M in annual sales and /or fewer than 200 employees that supply raw materials or finished goods for an end user.

- *Computer Aided Production Management*

The IFIP Working Group 5.7 Integrated Manufacturing Systems runs this list for researchers and practitioners involved with computer aided production management in manufacturing and other industries.

A general posting was sent to each of these mailing lists outlining the project and giving a brief description of an 'expert'. It asked subscribers to nominate process re-design experts to whom a questionnaire could be sent. Some of the list members nominated themselves, others suggested names. The researcher disregarded some of the nominees at this time as their experience or background did not meet that required. The nominees remaining became the sample to be surveyed and each was sent by e-mail a questionnaire accompanied by completion instructions and definitions of Process Improvement Actions and Performance Requirements. Those surveyed were given approximately two weeks to respond, a reminder was then sent to solicit more responses.

There was inevitably bias introduced by this method as the decision to use mailing lists to access experts automatically excluded many. Whilst the mailing lists are accessible to people world-wide they are primarily subscribed to by Britons and Americans. There were members of the final sample from Europe, Brazil, Mexico and Russia but essentially the sample used was biased towards a British or American perspective.

Selection of potential participants from the mailing list could not be performed randomly as not all who subscribed to the list were eligible experts, hence the request for nominations.

This method of sample selection resulted in a sample consisting of process re-design experts who whilst not randomly selected as such were included in the survey independent of the researcher.

7.4.2.2 Survey response rate

The non-response to surveys is another area where there is potential to introduce bias and errors (Fink, 1995a). Non-response error is concerned with the degree to which those who respond and those who do not respond differ. If they differ then the sample may not be a true representation of the population. Response rates within Production and Operations and Management research should be above 20% (Malhotra and Grover, 1998).

When the call was put out on the mailing lists for process re-design experts 69 such people volunteered to participate. Not all of these volunteers completed a questionnaire, 4 were not considered suitable, as they did not meet the criteria of an expert. The remainder were sent a copy of the questionnaire along with definitions of the variables used within it. Of those sent out, a total of 30, some 46% were returned.

A reminder was also sent to those who had not responded by the required date in order to increase the response rate.

The main reasons for non-response were considered to be:

- The size of the questionnaire. Despite the preliminary and pilot testing the questionnaire was still seven pages long. It is possible that once they received it some people did not have the time or did not want to complete it.

- Participants realising that they did not have sufficient experience to complete the questionnaire. Three of the volunteers gave this as their reason for not responding to the questionnaire.

Neither of these implies bias. Where volunteers did not respond due to a lack of experience their non-response actually improves the strength of the sample surveyed.

7.4.2.3 Sample size

The sample size is the number of participants that need to be surveyed to improve data stability and reliability and to strengthen the significance decisions made from the data analysis (Chow, 1996).

It is not the size alone that contributes to improved results but also pureness of the sample. As this research was aiming to gather the opinion of experts the researcher considered the pureness of the sample to be more important than the size of the sample. Therefore a trade-off was made between having few expert respondents rather than a greater number of less experienced respondents that may not be considered experts (Chow, 1996).

Roscoe (1975) offers a rule of thumb that sample sizes of 30 to 500 are appropriate for most research. The required sample size for this research was set at 30. Small sample sizes such as this are common in Productions and Operations Management research especially when the research is exploratory as in this instance (Filippini, 1997).

The final number of questionnaires analysed was 29. One respondent was excluded from the analysis, as it did not appear from his characterisation data that he had any manufacturing experience and therefore did not meet the criteria for expert.

The final sample included 18 practitioners, 10 consultants and 1 academic.

- Practitioners

The majority of the sample were from the automotive (7) or the electronics sector (4). Other industrial sectors represented in the sample were aerospace and defence (2), medical equipment manufacture (1), bicycle manufacture (1), toy manufacture (1) and unspecified manufacturing (2). Some had worked in several of these sectors.

With regard to the size of company of which the practitioners had experience, 9 had experience of all sizes of company, 7 of large companies only and 2 of small and medium companies.

The sample included managers of process improvement projects, business process specialists, a Director of Operations, a Supply Chain Director, an Operations Manager and a Vice President. The companies for which they worked included Goodyear, Lego, Racal, Northrop Grumman and Siemens.

- Consultants

A majority of the consultants (8) stated that they had experience from a variety of manufacturing sectors, 1 specified experience in aerospace, electronics and semi-conductor manufacture and 1 in electronics.

With regard to the size of company of which the consultants had experience, 3 had experience of all sizes of company, 2 of large companies only, 3 of medium and large companies, 1 of small and medium companies and 1 of small companies only.

The consultancies for which they worked included CSC and Arthur Andersen.

- Academic

The experience of the academic was primarily from large aerospace and automotive companies.

With regard the expertise of the final sample they had 465 years of process re-design experience between them, an average of sixteen years each. Individually the minimum was three years experience and the maximum fifty years, many having ten or twenty years.

7.5 Conclusion

This chapter has detailed the development of the questionnaire used within this research, the survey sample to which it was administered and possible sources of error and bias. It can be seen that through the stages of preliminary and pilot design that the validity and reliability of the questionnaire was ensured and the specific actions taken highlighted.

The survey sample to which the questionnaire was administered was discussed in terms of size, purity and response rate. It is acknowledged that the sample does have a bias towards American and British participants.

Having developed the final questionnaire and decided upon the survey sample the questionnaire was administered to the participants. The analysis of the responses and associated findings are discussed in Chapters 8 and 9.

Chapter 8 - Questionnaire analysis method

In Chapter 7 the design of the questionnaire used within this research and the survey sample to which it was administered were discussed. This chapter discusses the analysis and initial findings of the completed questionnaires.

The data from the questionnaires was analysed using both descriptive statistics, which gave an overall picture of the data, and inferential statistics that were used to draw conclusions from the data regarding the ranking of Process Improvement Actions and the statistical strength of those rankings. The results of the inferential statistics are discussed in Chapter 9.

The results of the initial descriptive statistics, using the median and the mode of the data are presented in Matrix 1. This shows only the Process Improvement Action to Performance Requirement links considered to be strong in relation to the scale used. The definite patterns emerging from these results are discussed.

Finally the process for hypothesis testing is introduced. This outlines the hypothesis tested, the acceptable levels for acceptance or rejection of hypothesis, and justification for the statistical test used; the Wilcoxon Matched Pairs Test.

8.1 The questionnaire data

Analysis of the questionnaire data was conducted using the computer software programme SPSS 9.0. A computer based statistical analysis programme was used, as opposed to manual calculations as it saves time in analysis and reduces the possibility of errors in calculations.

The data from the questionnaire was entered into the data editor with each of the respondents listed on the vertical and each of the statements linking Performance Requirements and Process Improvement Actions listed as variables (T1A, T1B etc.) along the horizontal. These were coded so that each of the Process Improvement Actions had a unique letter to identify it and comparisons could be made easily between the individual results of questions after analysis.

Questionnaire variable coding

The questionnaire variables were coded as follows:

Performance criteria

T - Time

C - Cost

Q - Quality

F - Flexibility

followed by the question number 1 to n then the letter denoting the Process Improvement Action.

Process Improvement Action

Letters were allocated sequentially as Process Improvement Actions appeared in the questions.

A - *Reduce the number of activities within a process*

B - *Perform activities in parallel rather than sequentially*

C - *Eliminate non-value-adding activities*

D - *Move activities out of the process - to the customer*

E - *Move activities out of the process - to the supplier*

F - *Re-sequence activities*

G – *Move activities into the process*

H – *Introduce a case manager, worker or team*

I – *Standardise*

J – *Error Proof*

K – *Make the people or teams performing an activity responsible for it*

L – *Create alternative routes or paths through the process*

M – *Use IT or technology to enable activities*

Thus each link consisted of a Performance Requirement letter and number and a Process Improvement Action letter.

Some of the questionnaire respondents failed to answer all the questions and therefore there were some missing values when the data was entered. There appeared to be several reasons for this.

- Occasional answers missed. It appeared that the respondent had overlooked a question when completing the questionnaire.

- Complete questions missed. Some of the questions were alike but appeared under more than one performance criterion such as set-up time and changeover time. Some respondents commented on this and did not complete the second question.

- Frequent missed answers. One of the respondents frequently missed answers. These answers did not appear to be related to any particular Process Improvement Action and occurred randomly. It is assumed that in these cases the respondents did not have an opinion on the link.

In all of the cases of missing data the sample size used in the analysis was adjusted accordingly.

At the end of the questionnaire there was a set of classification questions regarding the background and experience of the respondent. Each of the possible replies to these questions had to be entered onto SPSS as a separate variable. For example, one of the questions asked is whether the background of the respondent is in general management, quality, IT etc. Each of these is entered as a separate variable. If a respondent indicates their background to be quality then a 1 is entered under the quality variable to represent yes and 0 is entered under the other options to represent no.

8.2 Matrix 1 – Performance Requirement to Process Improvement Action links

Matrix 1 shows the strong links between the Process Improvement Actions and the Performance Requirements derived from the questionnaire data. These initial links were drawn from the data using basic descriptive statistics, the median and mode. This basic analysis was simple and the links and priorities established gave a general picture of the data and what the results of further more advanced inferential statistical analysis might look like.

8.2.1 Descriptive statistics

Descriptive statistics (Clegg 1982, Gravether and Wallnau 1999) describe data in terms of frequencies, averages and distributions, which enable any trends or patterns in the data to be seen. As the Likert scale used within the questionnaire resulted in ordinal data as discussed in Chapter 7, the median and the mode were used for Matrix 1.

Median

The median of a set of numbers is the central number of the row of numbers when they are arranged in ascending or descending order (Lewis and Traill 1999, Clegg 1982).

The median is particularly appropriate for the questionnaire data as it is unaffected by the extreme values in the data (Lewis and Traill, 1999). In other words if a respondent has scored 1,2 or 3 for a link where the others have scored 4 or 5 the median will remain at 4 or

		A	B	C	D	E	F	G	H	I	J	K	L	M
	Process Improvement Action / Performance Requirement	Reduce the number of activities	Perform activities in parallel	Eliminate NVA activities	Move activities out of process - to customer	Move activities out of process - to supplier	Resequence activities	Move Activities into the Process	Introduce a Case Manager or Team	Standardise	Error Proof	Make the people performing an activity responsible for it	Create alternative routes or paths through a process	Use IT or technology to enable activities
T	Time													
T1	Manufacturing Lead-time	★	★	★										
T2	Cycle Time	★	★	★										
T3	Lead-time Reliability									★	★	★		★
T4	Rework Time	★								★	★	★		
T5	Set-up Time	★		★						★		★		
T6	Inspection Time									★	★	★		
T7	Distance Travelled	★		★			★							
T8	Output Rate	★	★	★						★		★		
C	Cost													
C1	Cost of Rework	★								★	★	★		
C2	Machine Productivity	★		★							★	★		
C3	Labour Productivity	★		★						★	★	★		
C4	Cost of Inspection			★						★	★	★		
C5	Cost of Labour	★		★		★						★		
C6	Cost of Inventory					★				★		★		★
C7	Cost of Material									★	★			
C8	Cost of Scrap								★	★	★	★		
C9	Cost of WIP	★	★	★		★								
C10	Total Operational Cost	★		★		★				★	★			
C11	Labour Efficiency	★		★					★	★		★		
C12	Machine Efficiency	★		★						★	★	★		★
Q	Quality													
Q1	Quantity of Rework								★	★	★	★		
Q2	Quantity of Scrap									★	★	★		
Q3	Yield	★							★	★	★	★		
Q4	Defects per Batch								★	★	★	★		
Q5	Rework Labour	★								★	★	★		
Q6	No. of Inspection Activities									★	★	★		
Q7	Non-conforming Product								★	★	★	★		
F	Flexibility													
F1	Lead-time to make a Product	★	★	★						★				
F2	Range of Products													
F3	Predictable Output								★	★	★	★		
F4	Changeover Time	★	★	★						★		★		
F5	Bottlenecks	★	★	★		★	★						★	

Figure 8.1 - Matrix 1 - Strong links established from descriptive statistics

5. One respondent who has a different opinion to the rest does not affect the results. The conclusion to be drawn from a median of 4 or 5 is that the general opinion is that the link is strong.

Mode

The mode is the score that appears the most often in a set of numbers (Lewis and Traill 1999, Clegg 1982). It gives an indication of the most common opinion regarding the strength of a link. It is possible that a majority of the respondents do not share the same opinion and that their responses are spread across the other possible scores.

8.2.2 A 'strong' link

The Likert scale used in the questionnaire allowed respondents to indicate their opinion regarding the strength of a link between a Performance Requirement and a Process Improvement Action on a scale from 1-No Effect to 5-Strong Effect.

A score of 3 was considered to have only a limited effect on the Performance Requirements and therefore any links with a median and/or mode of 3 or below were not regarded as strong.

Matrix 1 shows the strong links between the Process Improvement Actions and the Performance Requirements derived from the questionnaire data. Whether a link could be considered strong was based upon a combination of the median and the mode calculated from the respondents' scores on the questionnaire. To be included the link had to have a median and a mode of 4 or 5.

A combination of the median and mode was used as using one or the other in isolation could lead to the misinterpretation of the data. To interpret the results on the basis of the median alone would lead to a conclusion based on the opinion of the majority, yet the most common score may be different. Conversely to draw conclusions based on the mode alone would lead to a conclusion based on the most popular score even though it may not be the opinion of the majority. Therefore a link must satisfy the criteria of scoring a 4 or 5 for the median and mode to be considered a strong link.

All of the possible links between Performance Requirements and Process Improvement Actions included in the questionnaire were analysed using descriptive statistics. The strong links established are included in the matrix. No attempt is made to rank these links on the basis of the descriptive statistical tests.

8.3 A Description of Matrix 1

Matrix 1 shows the strong links established as a result of the descriptive statistical analysis of the questionnaire data. The statistical results are included in Appendix 6. Since the links shown in Matrix 1 are to be further refined using inferential statistics the results shown are discussed here in broad terms only.

There are very obvious patterns in the results shown on the matrix, the main of these being:

- **Redundant Process Improvement Actions**

The analysis of the questionnaire data did not establish a strong link dealing with *Move activities out of the process - to the customer* or *Move activities into the process.* It would appear that the questionnaire respondents did not consider these Process Improvement Actions as appropriate for improving performance or that they did not understand them.

- **Redundant Performance Requirements**

The Performance Requirement to Increase the Range of products is not strongly linked to any of the Process Improvement Actions, suggesting that none of them would have a strong effect on improving performance in this area.

- **Popular Process Improvement Actions**

Some of the Process Improvement Actions such as *Standardise* are linked to many of the Performance Requirements and could therefore be used to improve many different areas of performance.

- **Quality trends**

An obvious pattern emerges in the links regarding quality. All of the Performance Requirements classified under quality are strongly linked to the Process Improvement Actions of *Standardise*, *Error Proof* and *Make the people or teams performing an activity responsible for it.* This also applies to the quality related Performance Requirements of Rework time, Cost of rework and Cost of scrap. Possible reasons for this are discussed in Chapter 9.

- **Discussion of dummy links**

The questionnaire contained dummy links as discussed in Chapter 7 that were included to minimise the tendency of the respondents to tick straight down a column without giving sufficient consideration to the answer. These were actually the weak links from the preliminary questionnaire so when analysed in the final questionnaire they should not have emerged as strong Process Improvement Actions.

There were eleven dummy links spread randomly throughout the questionnaire. These were the following:

- To reduce cycle time..... *Move activities into the process*
- To reduce set-up time..... *Introduce a case manager, worker or team*
- To reduce the distance travelled..... *Error Proof*
- To reduce the cost of rework..... *Perform activities in parallel rather than sequentially*
- To reduce the cost of inventory..... *Move activities into the process*
- To reduce the cost of scrap.... *Perform activities in parallel rather than sequentially*
- To reduce the quantity of rework...*Create alternative paths or routes through the process*
- To increase yield .....*Reduce the number of activities within a process*
- To reduce defects per batch..... *Re-sequence activities*
- To reduce non-conforming product....*Perform activities in parallel rather than sequentially*
- To achieve a predictable output when conditions change ....*Move activities out of the process to the customer*

Ten of these did not emerge as strong links as would be expected. This reassures the researcher that the questionnaire design is sound and that the respondents were not just ticking randomly but were completing the questionnaire thoughtfully.

The remaining dummy Q3A *'To increase yield...Reduce the number of activities within a process'* emerged as a strong link. It is unlikely that this is a result of the respondents not giving thought to their answers as it is the first Process Improvement Action of the question. The respondents should have just had a brief break from ticking answers to read the Performance Requirement. *Reduce the number of activities within a process* is however one of the most popular of the Process Improvement Actions, so respondents may be more familiar with it than some of the others and so more likely to suggest it.

8.4 Ranking of the Process Improvement Actions

The strong links established and shown in Matrix 1 indicate which of the Process Improvement Actions a practitioner should consider implementing to achieve improvements in a specific Performance Requirement. It is also possible to establish rankings for the Process Improvement Actions so that a priority order can be suggested to practitioners. The strong links that emerged from the descriptive statistics were ranked using the inferential statistics, in particular the Wilcoxon Matched Pairs Test (Siegel and Castellan 1988, Lewis and Traill 1999).

8.4.1 Inferential statistics - The Wilcoxon Matched Pairs Test

The Wilcoxon Matched Pairs Test took the questionnaire data, ranked the Process Improvement Actions in order of reported effect and tested for significant differences between them.

Where a Process Improvement Action is found to be significantly stronger than another Process Improvement Action it can be confidently stated that the difference results from the questionnaire data and is not due to chance. If this is the case then the stronger Process Improvement Action can be ranked above the other. It can be recommended as having a stronger effect on a Performance Requirement than the other one.

To perform this analysis a series of possible hypotheses were presented and statistical tests were conducted on the questionnaire data to confirm or reject these hypotheses.

8.4.2 Hypothesis testing

To ensure that hypotheses were accepted or rejected correctly and to enable future researchers to repeat the tests if required an objective procedure must be employed (Siegel and Castellan, 1988). This research takes the following approach to incorporate the procedures in Siegel and Castellan (1988) and Sanders et al (1985).

1. State the null and alternative hypotheses
2. Choose an appropriate test for testing the null hypothesis
3. Specify a significance level
4. Determine the sampling distribution
5. Define the regions of rejection
6. Perform the statistical tests
7. Accept or reject the null hypothesis

The null hypothesis

The null hypothesis, H_0 states the value or relationship between variables as assumed before any sampling or experimentation (Sanders et al, 1985). Siegel and Castellan (1988) refer to it as the hypothesis of 'no effect' and it is generally expected to be rejected. If the null hypothesis is rejected then the alternative hypothesis H_1 is accepted.

Research specific hypothesis

Null hypothesis: There is no significant difference between the effect that one of the Process Improvement Actions may have on the Performance Requirements and the effect that the other of the pair tested may have.

Alternative hypothesis: There is a significant difference between the effect that one of the Process Improvement Actions may have on a Performance Requirement and the effect that the other of the pair tested may have.

8.4.3 Test selection - The Wilcoxon Matched Pairs Test

The Likert scale used within the questionnaire is treated as an ordinal scale in this research as discussed in Chapter 7 therefore the data generated was analysed using a non-parametric inferential statistical test (Wright 1997, Clegg 1982). It is recognised that other researchers may use a parametric t-test for such data. This matter will be discussed in section 8.5.

Inferential statistical tests are used to draw conclusions from data, to ensure that those conclusions are significant and that it can be stated confidently that they are 'real' and are not due to chance. Tables of possible statistical tests indicate which tests are appropriate dependent on the conclusions to be drawn from the data, the sample, and whether parametric or non-parametric tests are required (Clegg 1982, Siegel and Castellan 1988).

In the case of this research:

- Conclusions required - The outcome of the statistical analysis should enable the strong links to be ranked for each Performance Requirement so that a priority order can be given for the implementation of the Process Improvement Actions.

- Sample

The questionnaire was not designed to compare two groups of respondents but to collect specific information from a set of process re-design experts.

The questionnaire was administered to one set of experts and thus resulted in one set of data from a single sample. Therefore in order to test whether the differences between links were significant each of the possible links was compared to all of the other possible links through 'paired comparisons'. Thus comparing all of the possible links against each other, with the aim of ascertaining any significant differences.

- Whether the data is suitable for parametric or non-parametric statistical tests

Since the data is of ordinal level then non-parametric statistical tests should be used.

Using the statistical tables in Siegel and Castellan (1988) and Emory (1995) the test selected for the analysis of the questionnaire data was The Wilcoxon Matched Pairs Test. The Wilcoxon Matched Pairs Test does not assume normal distribution of data and is appropriate for use on ratio, interval or ordinal data (Wright, 1997).

The Wilcoxon Matched Pairs Test is an extension of the basic sign test. When considering a pair of observations the basic sign test indicates which is the greatest of the pair (Siegel and Castellan, 1988). The Wilcoxon Matched Pairs Test also indicates the magnitude of this difference (Siegel and Castellan, 1988). By calculating the direction and the magnitude of the differences between pairs it can be determined whether the differences are real significant differences (Sanders et al, 1985).

8.4.4 Statistical significance and probability levels

Statistical significance (α) refers to the probability of rejecting the null hypothesis when in fact the null hypothesis should have been accepted (Meddis 1984, Fink 1995b), in other words finding a significant difference between two variables where one does not actually exist, a type 1 error. The probability of this occurring, the significance level, is selected and set by the researcher depending on the level acceptable and applicable to the research. According to Emory (1985) the most frequently used level of significance is 5% (0.05), which according to Wright (1997) is convention. The researcher considers a 5% risk of committing a type 1 error acceptable for Production and Operations Management so a significance level of 0.05 was adopted in line with 'convention'.

8.4.5 The sampling distribution

Inferential statistical tests result in test statistics, each of which has a particular sampling distribution (Fink 1995b, Siegel and Castellan 1988). The sampling distribution is the theoretical distribution that would result from taking all of the possible samples, of the same size, from the same population, selected randomly (Siegel and Castellan, 1988). As each distribution has different areas under which the null hypothesis would be rejected or accepted this must be decided so that the appropriate statistical table can be used to find the significance level.

In general the test statistic produced from a non-parametric Wilcoxon Matched Pairs Test is T however when calculating the statistic using SPSS the resulting test statistic is z. This is *'the standardized normal approximation to the test statistic...'* (Corston and Coleman, 2000).

According to Siegel and Castellan (1988), z should be used where the number of subjects analysed by the Wilcoxon Matched Pairs Test exceeds 15. When this is the case *'....it can be shown that the sum of the ranks, T+, is approximately normally distributed.....'* and the test statistic z is used. Therefore an alternative statistical table of z test statistics is used from which to ascertain the significance.

8.4.6 Region of rejection

There are two possible areas of rejection under a sampling distribution. In the case of a one-tailed test it is at one end of the sampling distribution and in the case of a two-tailed test it is located at each end of the sampling distribution. If the alternative hypothesis suggests that the difference be in a certain direction then a one-tailed test can be used, if it does not state a direction then a two-tailed test should be used (Siegel and Castellan,1988). The alternative hypothesis for this research does not stipulate a particular direction therefore a two-tailed test is used. When using SPSS to calculate the test statistic for the Wilcoxon Matched Pairs Test the significance figure it gives is *'the asymptotic two tailed significance estimated from the normal approximation.'* (Corston and Coleman, 2000).

8.4.7 Calculating the test statistic

As discussed in section 8.1, the statistics for analysis of the questionnaire data, both descriptive and inferential were calculated using the SPSS software package. This is quicker and more accurate than calculating them by hand. The Wilcoxon Matched Pairs Test was conducted using SPSS and generated a z test statistic and a two-tailed significance figure. To interpret the test results correctly the procedure for manually calculating the test must be understood. It is summarised below:

1. Calculate the difference between the scores of each matched pair of observations taking into account whether it is a positive or a negative difference.
2. Rank the differences obtained (regardless of sign) starting with one for the smallest difference, two for the next smallest etc.
3. Re-affix the sign of the difference to the rank.
4. Sum the positive ranks to obtain T+ and the negative ranks to obtain T-.

   When the null hypothesis is accepted the sum of T+ and the sum of T- will be approximately equal i.e. there is no significant difference between them. Where they are exactly equal the significance level will be 1.
5. The smallest of the two is designated T, which can then be compared to the T value at the required significance on a statistical table.

   (Siegel and Castellan 1988, Lewis and Traill 1999)

8.5 Comparison with the t-test

As discussed in Chapter 7 the Likert scale used in the questionnaire was considered to be ordinal, and the data was not assumed to be normally distributed. Therefore non-parametric statistical tests were used. The Wilcoxon Matched Pairs Test is the non-parametric equivalent of the more widely known t-test (Clegg 1982, Lewis and Traill 1999) used when checking for significant differences between matched pairs of data. The t-test is considered more powerful than the Wilcoxon Matched Pairs Test but only when the data meets the assumption for use of parametric tests, which it does not in this case (Wright, 1997). According to Emory (1985) non-parametric tests are *'the only technically correct tests to use with ordinal data,....'* and whilst parametric tests have greater efficiency, non-parametric tests still have efficiencies as high as 95%.

Since the calculation of test statistics is quick and simple when using SPSS the t-test statistics for the matched pairs of questionnaire data were also calculated. These are not used to support the results presented in the next chapter. The results of the t-test were compared with the results of the Wilcoxon Matched Pairs Test. Whilst the test statistic figures resulting from the two tests are not exactly the same, the rankings established match. This offers further confidence in the findings.

8.6 Conclusion

This chapter outlined the descriptive analysis conducted on the questionnaire data. The results were presented in Matrix 1 from which some interesting patterns emerged. These included the redundancy of some of the Process Improvement Actions and Performance Requirements and a strong consensus of opinion regarding the ways to improve quality performance. These will be discussed further in Chapter 9 with regard to the Wilcoxon test results.

Whilst the results of the descriptive statistics allow the strong links to be identified they do not allow for any rankings to be made amongst the Process Improvement Actions nor do they allow any conclusion to be drawn regarding the significance of the differences. This is achieved through the use of inferential statistics. The null hypothesis, that there will be no difference between the effect of two Process Improvement Actions was stated, the parameters for acceptance or rejection justified and the test used, the Wilcoxon Matched

Pairs Test introduced.

The results of the Wilcoxon test for individual questions are presented in Chapter 9, in which the overall results in the context of current business process re-design approaches are also discussed.

Chapter 9 - Questionnaire findings

Chapter 8 described the statistical tests that were used to analyse the questionnaire data; this chapter presents the findings of the statistical analysis. The results of the Wilcoxon Matched Pairs Test are used to rank Process Improvement Actions according to the strength of effect that the questionnaire respondents believe they have on specific Performance Requirements. These rankings enable the links established between Performance Requirements and Process Improvement Actions to be presented in priority order for implementation. The results of individual questions, the popularity of Process Improvement Actions and trends emerging are discussed.

9.1 The results of the Wilcoxon Matched Pairs Test

The Wilcoxon test considered all of the possible Process Improvement Actions for each question, comparing each against the others so that all possible combinations were tested. This analysis allowed conclusions to be drawn from the questionnaire data regarding where there were significant differences between Process Improvement Actions, allowing it to be confidently stated that one has a greater effect on the Performance Requirement than the other one and can therefore be ranked above it.

When using the results of the Wilcoxon test to formulate rankings, rules were established regarding the interpretation of the significance levels generated so that meaningful conclusions could be drawn. This was particularly relevant for the cut-off point for inclusion and where the statistics did not show clear significant differences for all of the Process Improvement Actions.

9.1.1 Ranking of the Process Improvement Actions

The Process Improvement Actions were ranked according to the results from the Wilcoxon test and positioned on a continuum from the one with the most effect on the Performance Requirement to the one with the least effect, for example, a ranking could run:

K (most effect)
E
F
A (least effect)

The significance levels for each of the relevant paired comparisons were then considered, to ascertain where Process Improvement Actions could be confidently ranked into separate levels. To continue with the example above paired comparisons were made using the Wilcoxon Test to ascertain a significance level (shown in brackets) between:

K & E (0.123)   K & F (0.090)   K & A (0.045)
E & F (0.070)   E & A (0.065)
F & A (0.065)

Where a significance figure is less than 0.05 it can be said that the null hypothesis is rejected and that a significant difference exists between the two Process Improvement Actions as discussed in Chapter 8. In this example the only significant difference is between K and A. They can therefore be placed on separate levels at either end of the continuum.

However none of the other comparisons resulted in significance figures that allow the Process Improvement Actions to be split onto separate levels. In these cases difficulties arise in interpreting the results.

According to the statistics, E and F cannot be separated from K, since the significances are

0.123 and 0.090 respectively; neither can they be separated from A since the significance figures are both 0.065. This implies a continuum of rankings from K through E and F to A with no clear evidence to split them onto separate levels. Yet the statistics do support a significant difference between K and A. A decision rule must be established to draw meaningful conclusions from such results.

It is inevitable that for some of the questions significant differences will only be found between the two Process Improvement Actions that are the furthest apart in terms of their average score. This must be acknowledged when drawing any conclusions from the results. However ranking all of the Process Improvement Actions on the same level would result in the loss of information regarding the significant differences that do exist. It is important that this knowledge is retained as it highlights clear differences between the effects that different Process Improvement Actions have on Performance Requirements and gives confidence in recommending one Process Improvement Action over and above another. In such cases where significant differences exist between Process Improvement Actions they are placed on separate ranks with any Process Improvement Actions that are ranked between the two included in an intermediate level. In the example K and A would appear as top and bottom levels with an intermediate level between them containing E and F.

9.1.2 Inclusion of Process Improvement Actions

The findings do not present the results of every paired comparison possible for each Performance Requirement. They only include those where the link a between Performance Requirement and a Process Improvement Action was considered strong, that is with a median or mode of 4 or 5. This descriptive statistical analysis was described in Chapter 8. This means that when considering the Wilcoxon results a Process Improvement Action that was included may not be significantly different from one that was excluded. If they are not significantly different should the excluded Process Improvement Action now be included? This situation can cascade down through all of the Process Improvement Actions, particularly where they are close in terms of their averages. The outcome could be the inclusion of Process Improvement Actions with modes and medians of only 2 or 3 that are not classified as strong links according to the descriptive statistics. Therefore whilst the issue regarding significance levels is acknowledged the cut-off is retained to aid meaningful interpretation of the results.

9.1.3 Presentation of the results

Figure 9.1 shows the common format for the presentation of the findings. As an illustration it presents the findings of the example used in section 9.1.1 to explain the ranking of Process Improvement Actions. The Process Improvement Actions K and A are shown at the two extreme ends of an arrow with the associated significance level (0.045) labelling the left hand side of the arrow. E and F, which are placed in the intermediate level are shown at the right hand side of the arrow. They are presented one above the other (even though there is not a significance difference between them) to reflect the initial ranking in which E was positioned above F.

All of the findings are presented in the common format outlined in Figure 9.1, though how they actually look and how complicated they are depends on the actual results. The Wilcoxon test results are included in Appendix 7.

Figure 9.1 – Example format for presentation of results	
K: Process Improvement Action with most effect	K ↑
E: Intermediate Process Improvement F: Intermediate Process Improvement	0.045 E F
A: Process Improvement Action with least effect	A ↓

9.2 Individual question results

The Wilcoxon test results showed that for 44% of the Performance Requirements the significance results enabled the Process Improvement Actions to be ranked without an intermediate level as was discussed in 9.1.1. This included those with only one level of Process Improvement Actions.

The Wilcoxon test results and rankings for each of the Process Improvement Actions are presented in sections 9.2.1 to 9.2.4.

The aim of the ranking is to establish which of the Process Improvement Actions are considered to have the strongest effect on the Performance Requirements. This could be used to establish a priority for action in practice.

9.2.1 Time

T1: Reduce Manufacturing Lead-time	
C: Eliminate non-value adding activities	C ↑
A: Reduce the number of activities in a process	0.028 A
B: Perform activities in parallel, not sequentially	B ↓

There is a significant difference between C and B. Therefore they are on separate levels. A is not significantly different from C or B so sits in the intermediate level between them.

T2: Reduce Cycle-time	
C: Eliminate non-value adding activities	C ▲
A: Reduce the number of activities in a process	0.002 A
B: Perform activities in parallel, not sequentially	B ▼

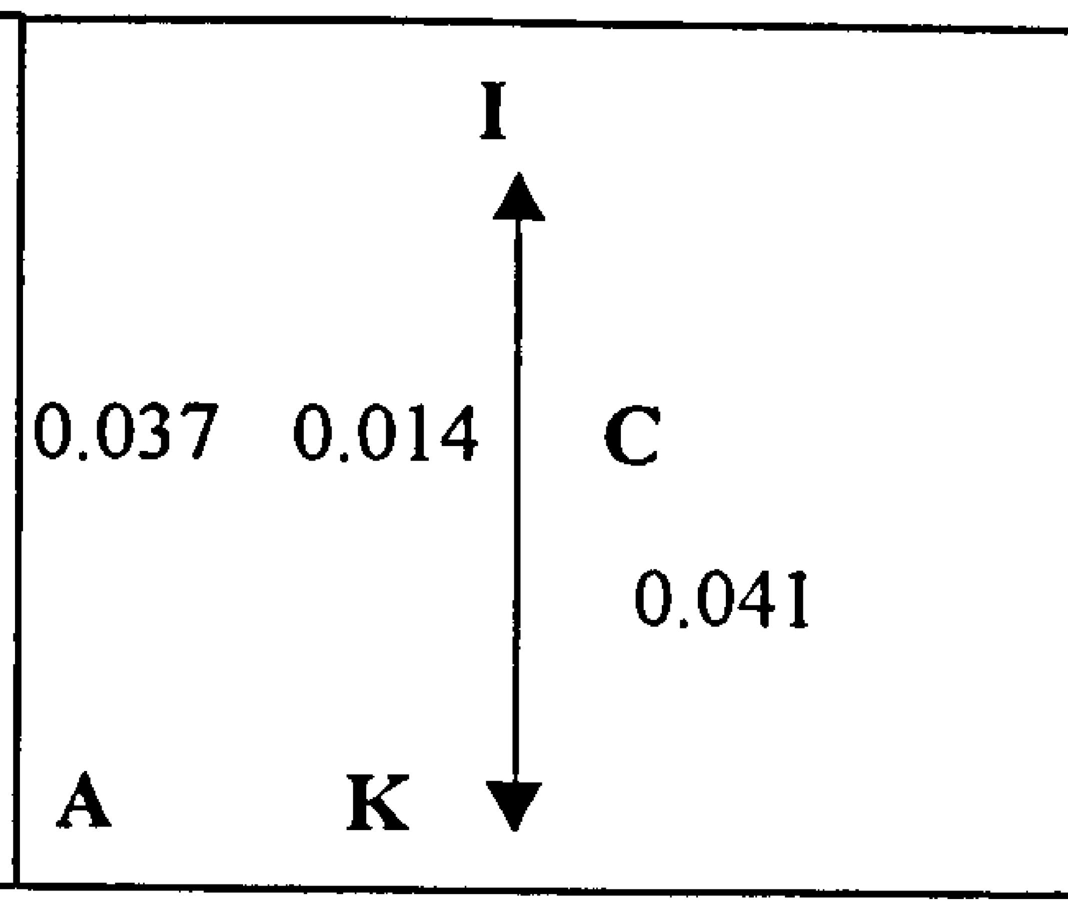
There is a significant difference between C and B. Therefore they are on separate levels. A is not significantly different from C or B so sits in the intermediate level between them.

T3: Improve Lead-time Reliability	
K: Make people responsible for activities	K ▲
I: Standardise J: Error Proof	0.032 I J
M: Use IT or technology to enable activities	M ▼

There is significant difference between K and M. Therefore they appear on separate levels. I and J are not significantly different from K and M so sit in an intermediate level.

T4: Reduce Rework Time	
J: Error Proof I: Standardise K: Make people responsible for activities	J I K ▲ 0.001 0.002 0.006
A: Reduce the number of activities in a process	A ▼

There are significant differences between J and A, I and A and K and A but not between J, I or K and themselves. Therefore J, I and K are included in the top level and A in the level below. In this case all of the possible Process Improvement Actions that were included in the question are included in the results as they all had a median and mode at 4 or 5.

T5: Reduce Set-up Time	
I: Standardise C: Eliminate non-value adding activities A: Reduce the number of activities in a process K: Make people responsible for activities	

There is a significant difference between I and A and I and K. Therefore they are on separate levels. C is not significantly different from I or A but is from K so it sits in the intermediate rank. The fact that C is significantly different from K supports its inclusion in the intermediate level.

T6: Reduce Inspection Time	
J: Error Proof I: Standardise K:Make people responsible for activities	**J I K**

There are no significant differences between J, I, and K. Therefore they all appear on the same level.

T7: Reduce Distance Travelled	
C: Eliminate non-value adding activities A: Reduce the number of activities in a process	C A
	0.007 0.024
F: Re-sequence activities	F

There are significant differences between C and F and A and F but not between C and A. Therefore C and A are included in the top level and F in the level below.

T8: Increase Output Rate	
I: Standardise C: Eliminate non-value adding activities A: Reduce the number of activities in a process	I C A
	0.019 0.010 0.018
K: Make people responsible for activities	K
B: Perform activities in parallel, not sequentially	B

There is a significant difference between I and B, C and B and A and B but not between I, C and A themselves. K is not significantly different from I, C, A or B so sits in the intermediate level between them. In this case all of the possible Process Improvement Actions that were included in the question are included in the results as they all had a median and mode at 4 or 5.

9.2.2 Cost

C1: Reduce Cost of Rework	
J: Error Proof K: Make people responsible for activities I: Standardise A: Reduce the number of activities within a process	J K I 0.005 0.012 0.012 ↕ A

There are significant differences between J and A, K and A and I and A but not between J, K and I themselves. Therefore J, K and I are included in the top level and A in the level below.

C2: Increase Machine Productivity	
C: Eliminate non-value adding activities J: Error Proof K: Make people responsible for activities A: Reduce the number of activities within a process	C 0.025 ↕ J K A

There is a significant difference between C and A. Therefore they are on separate levels. J and K are not significantly different from C or A, so sit in the intermediate level between them.

C3: Increase Labour Productivity	
C: Eliminate non-value adding activities K: Make people responsible for activities J: Error Proof I: Standardise A: Reduce the number of activities within a process	C 0.014 ↕ K J I A

There is a significant difference between C and A. Therefore they are on separate levels. K, J and I are not significantly different from C or A so sit in the intermediate level between them.

C4: Reduce Cost of Inspection	
I: Standardise J: Error Proof K: Make people responsible for activities C: Eliminate non-value adding activities	**I J K C**

There are no significant differences between I, J, K and C. Therefore they all appear on the same level.

C5: Reduce Cost of Labour	
C: Eliminate non-value adding activities A: Reduce the number of activities in a process E: Move activities out of the process - to supplier K: Make people responsible for activities	**C** 0.018 0.004 0.001 **A** 0.042 **E** **K**

There is a significant difference between C and E and C and K. Therefore they are on separate levels. E is not significantly different from K. Therefore C is at the top level and E and K at a separate level. A is significantly different from C and K so sits at a level between. It is not however significantly different from E, this still places it between C and E.

C6: Reduce Cost of Inventory	
I: Standardise	I
E: Move activities out of the process - to supplier	0.031 0.012 E
M: Use IT or technology to enable processes K: Make people responsible for activities	M K

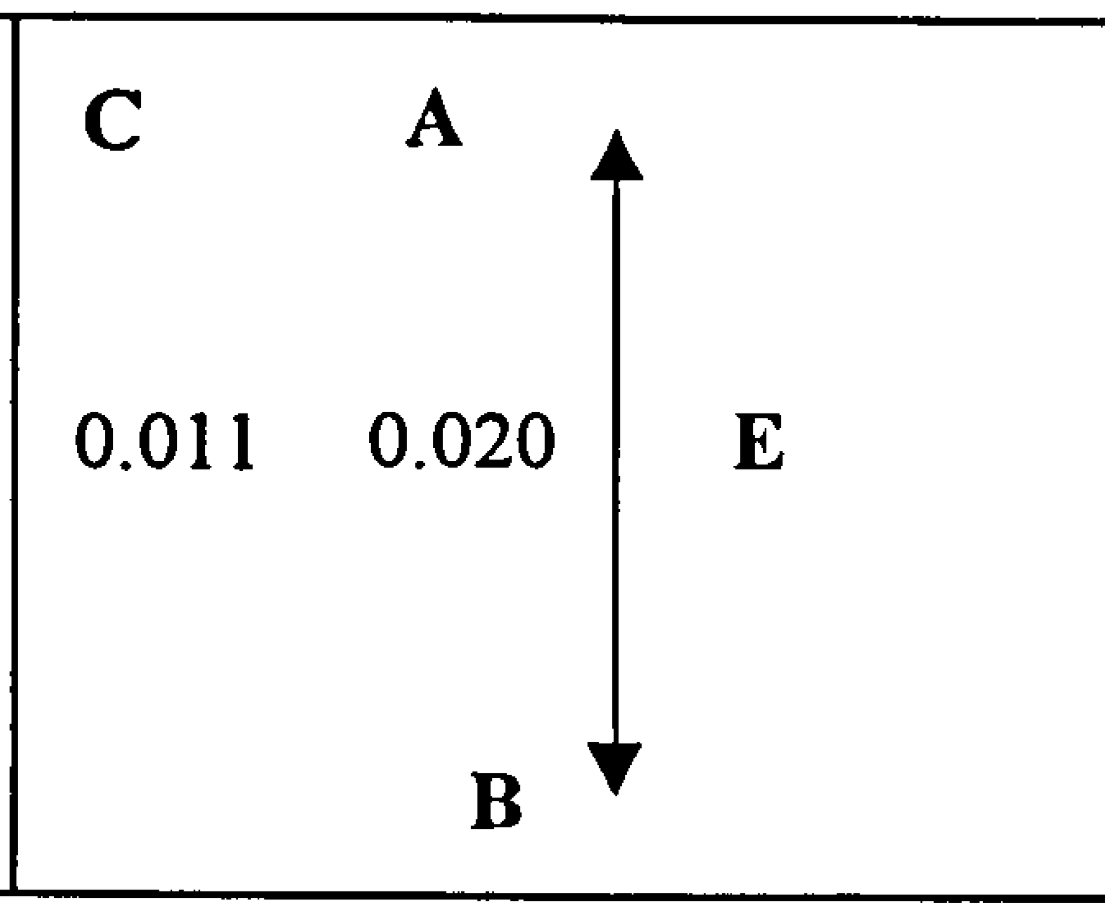
There is a significant difference between I and M and I and K but not between M and K themselves. Therefore they are on separate levels. E is not significantly different from I, M or K so sits in the intermediate level between them.

C7: Reduce Cost of Materials	
I: Standardise	I
	0.029
J: Error Proof	J

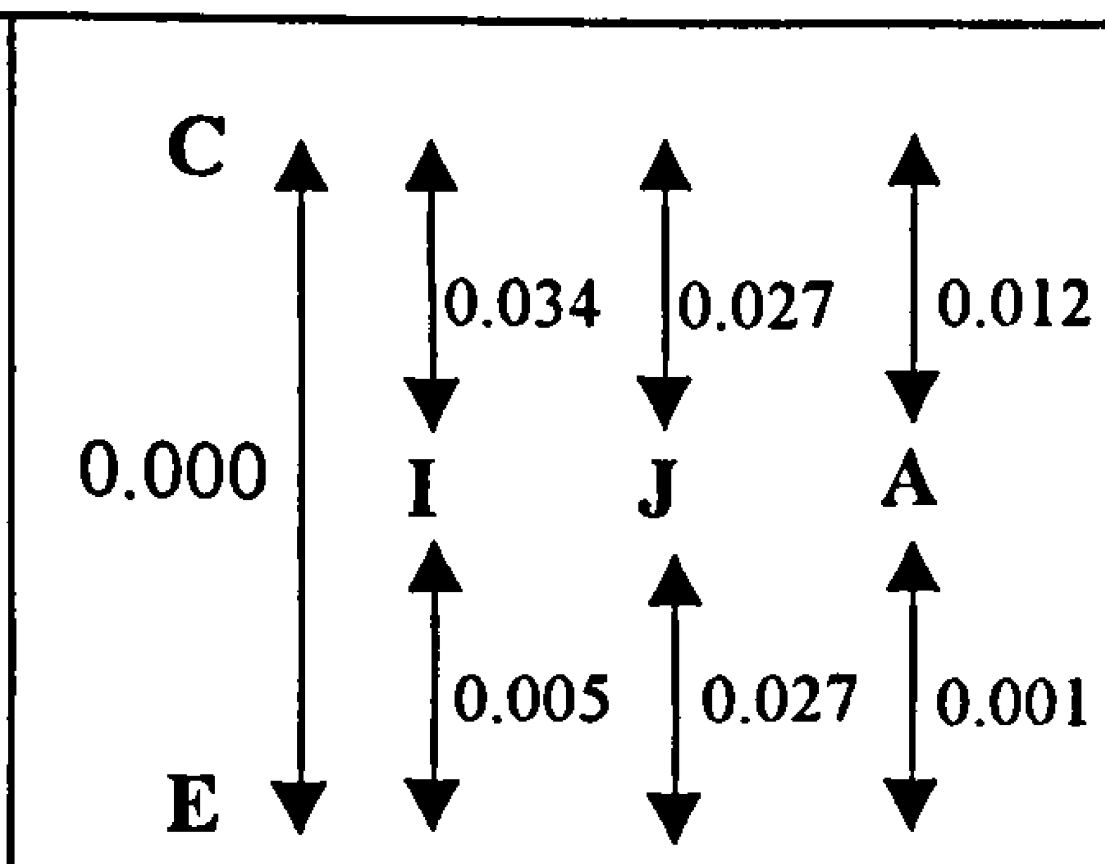
There is a significant difference between I and J. Therefore I is included in the top level and J in the level below.

C8: Reduce Cost of Scrap	
J: Error Proof K: Make people responsible for activities I: Standardise	J K I
	0.018 0.013 0.039
H: Introduce a case manager, worker or team	H

There are significant differences between J and H, K and H and I and H but not between J, K and I themselves. Therefore J, K and I are included in the top level and H in the level below.

C9: Reduce Cost of Work in Progress	
C: Eliminate non-value adding activities A: Reduce the number of activities within a process E: Move activities out of process - to supplier B: Perform activities in parallel, not sequentially	

There is a significant difference between C and B and A and B but not between C and A. Therefore they are on separate levels. E is not significantly different from C, A or B so sits in the intermediate level between them.

C10: Reduce Total Operational Cost	
C: Eliminate non-value adding activities I: Standardise J: Error Proof A: Reduce the number of activities in a process E: Move activities out of the process – to supplier	

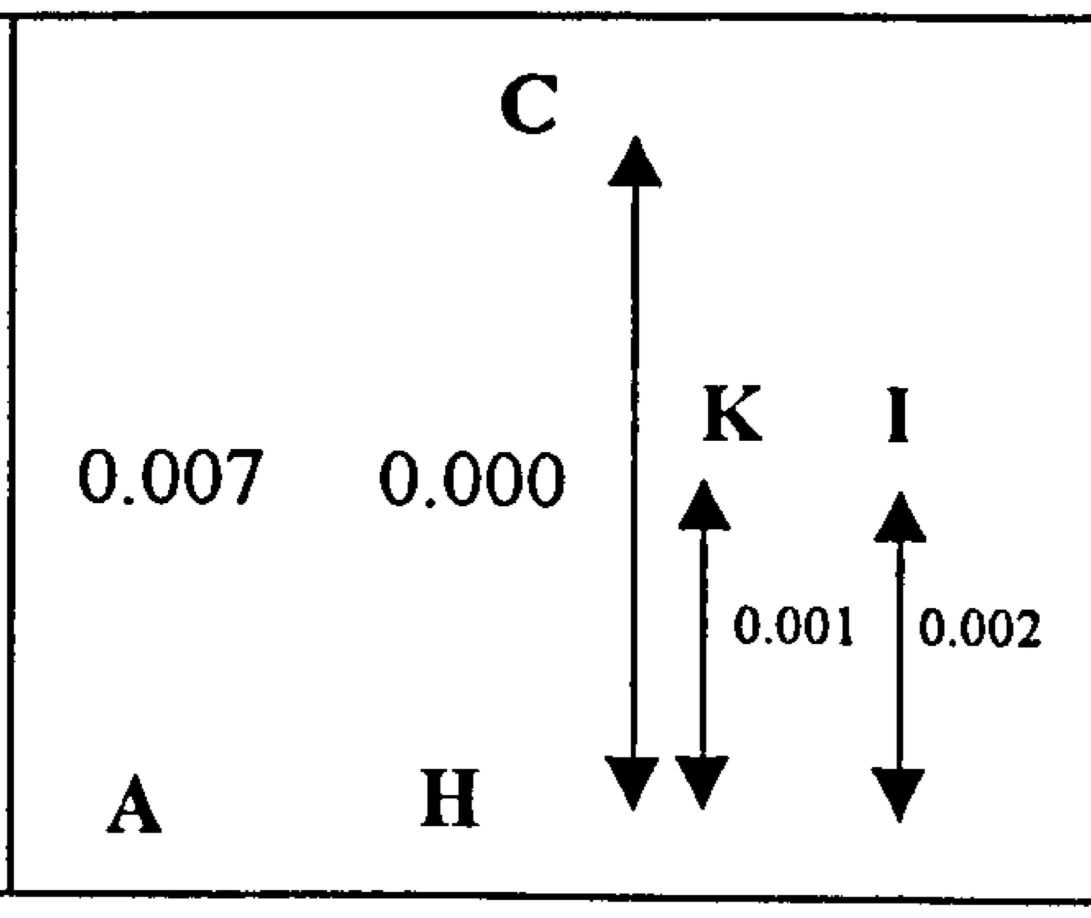
There are significant differences between C and E, C and I, C and J and C and A but not between I, J and A themselves. Therefore C is at the top level and I, J and A are in the level below. There are also significant differences between I and E, J and E and A and E. Therefore E sits in the level below I, J and A. In this case there are three clear levels, a top level containing C, an intermediate level containing I, J and A and a bottom level containing E.

C11: Increase Labour Efficiency

C: Eliminate non-value adding activities

K: Make people responsible for activities
I: Standardise

A: Reduce the number of activities in a process
H: Introduce a case manager, worker or team



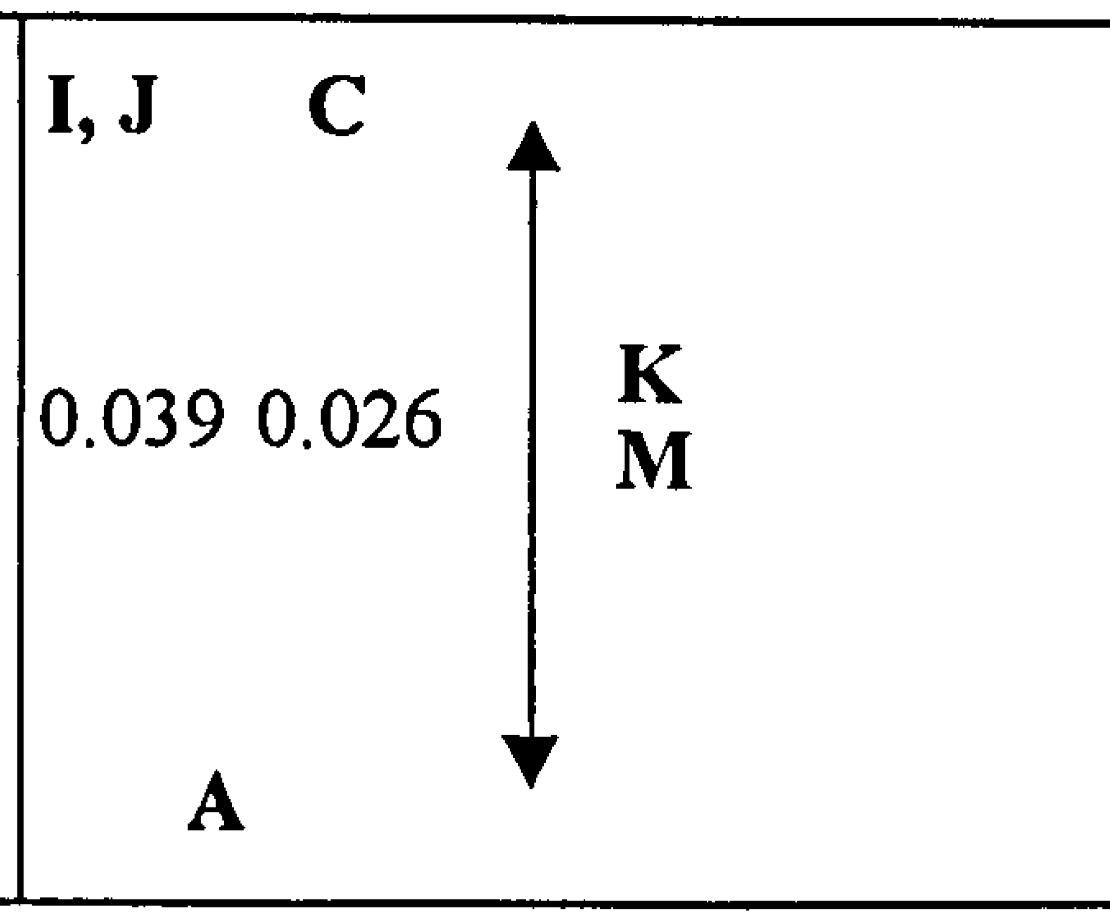
There is a significant difference between C and A and C and H but not between A and H. Therefore C sits on the top level and A and H on a separate level. K and I are not significantly different from C or A but are significantly different from H. The fact that K and I are significantly different from H supports their inclusion in the intermediate level. K and I are not significantly different to each other.

C12: Increase Machine Efficiency

I: Standardise/J: Error Proof
C: Eliminate non-value adding activities

K: Make people responsible for activities
M: Use IT or technology to enable activities

A: Reduce the number of activities in a process



There is a significant difference between I and A and C and A Therefore they are on separate levels. The significance between J and I is 1, this means that the sum of the positive ranks is equal to the sum of the negative so no discernible difference exits between them, as explained in Chapter 8 section 8.4.7. They have both being included in the top rank even though J is not significantly different from A. The difference between J and I is very close to being significant at 0.056.

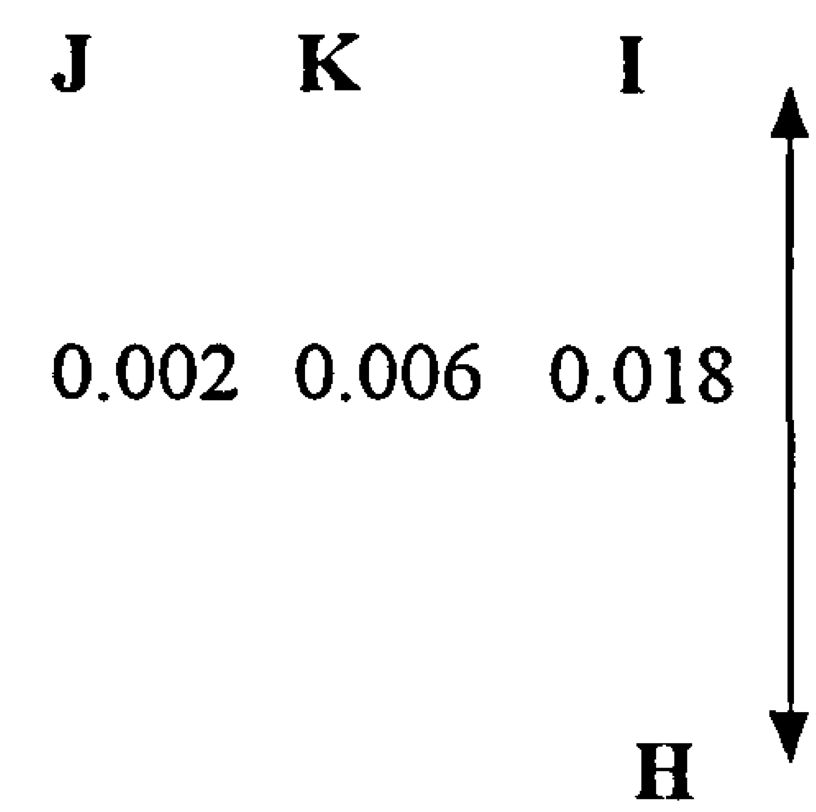
K and M are not significantly different from I, J, C or A so sit in the intermediate level between them.

9.2.3 Quality

Q1: Reduce Quantity of Rework

J: Error Proof
K:Make people responsible for activities
I: Standardise

H: Introduce a case manager, worker or team



There are significant differences between J and H, K and H and I and H but not between J, K and I themselves. Therefore J, K and I are included in the top level and H in the level below.

Q2: Reduce Quantity of Scrap

J: Standardise
I: Error Proof
K: Make people responsible for activities

J I K

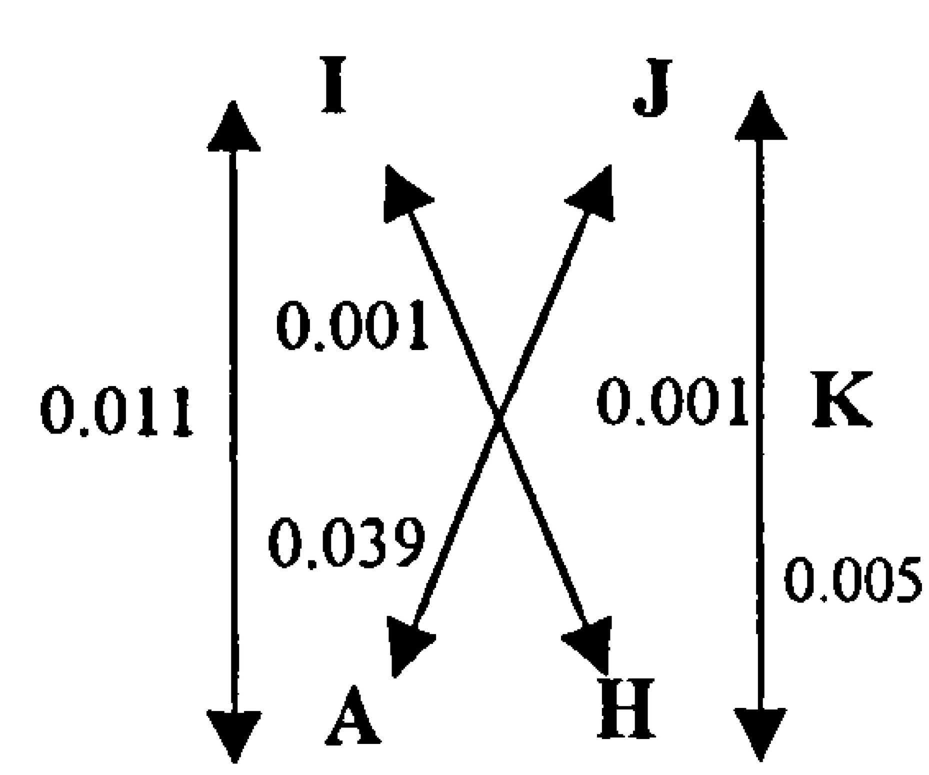
There are no significant differences between J, I and K. Therefore they all appear on the same level.

Q3: Increase Yield

I: Standardise
J: Error Proof

K: Make people responsible for activities

A: Reduce the number of activities in a process
H: Introduce a case manager, worker or team



There is a significant difference between I and A, I and H, J and A and J and H but not between I and J or A and H. Therefore I and J sit on one level and A and H on a separate level. K is not significantly different from I, J or A so sits in the intermediate level between them. The fact that K is significantly different from H supports its inclusion in the intermediate level.

Q4: Reduce Defects per Batch			
I: Standardise J: Error Proof K:Make people responsible for activities	**I**	**J**	**K**
	0.000	0.002	0.002
H: Introduce a case manager, worker or team			**H**

There are significant differences between I and H, J and H and K and H but not between I, J and K themselves. Therefore I, J and K are included in the top level and H in the level below.

Q5: Reduce Rework Labour			
J: Error Proof I: Standardise	**J**	**I**	
K: Make people responsible for activities	0.005	0.000	**K**
A: Reduce the number of activities in a process		**A**	

There is a significant difference between J and A and I and A but not between J and I. Therefore J and I sit on one level and A on a separate level. K is not significantly different from I, J or A so sits in the intermediate level between them.

Q6: Reduce the Number of Inspection Operations	
I: Standardise J: Error Proof K: Make people responsible for activities	I 0.011 J K

There is a significant difference between I and K. Therefore they are on separate levels. J is not significantly different from I or K so sits in the intermediate level between them.

Q7: Reduce Non-conforming Product	
I: Standardise J. Error Proof K: Make people responsible for activities H: Introduce a case manager, worker or team	I J K 0.000 0.001 0.001 H

There are significant differences between I and H, J and H and K and H but not between I, J and K themselves. Therefore I, J and K are included in the top level and H in the level below.

9.2.4 Flexibility

F1: Reduce Lead-time to Make a Product	
C: Eliminate non-value adding activities I : Standardise A: Reduce the number of activities in a process B: Perform activities in parallel, not sequentially	C I A B

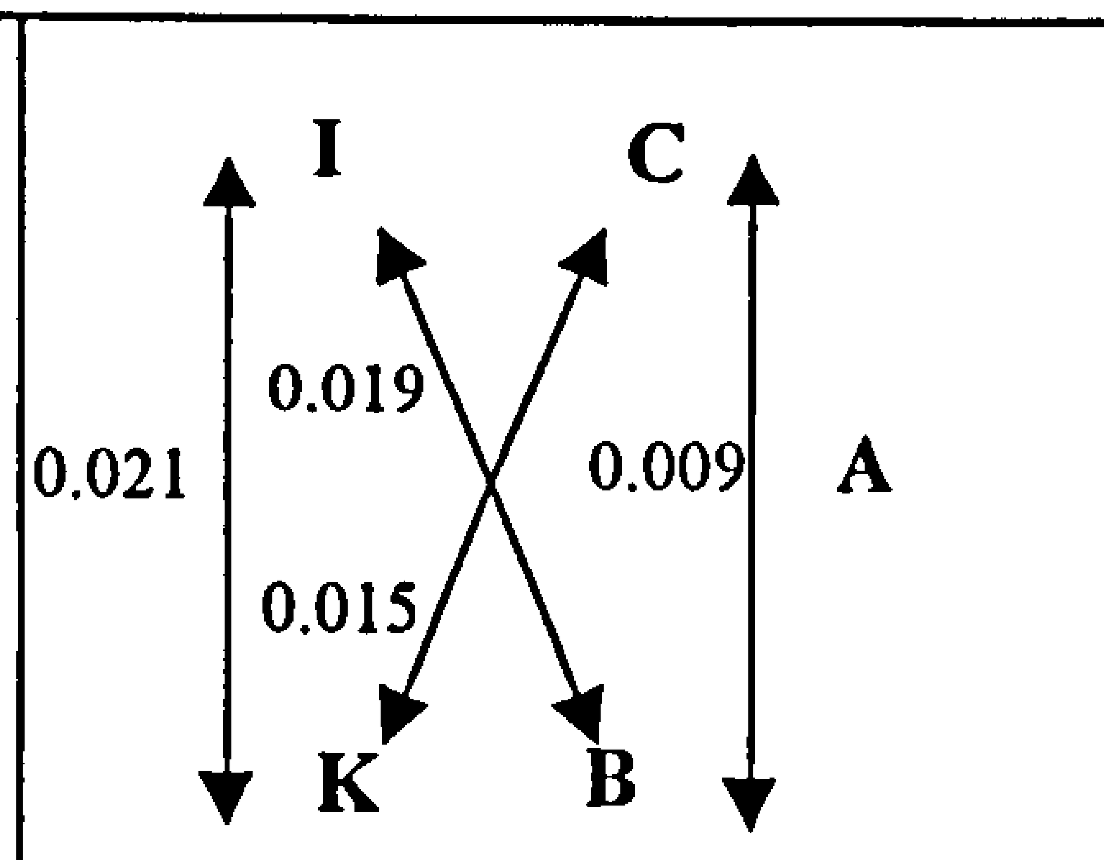
There are no significant differences between C, I, A and B. Therefore they all appear on the same level.

F2: Increase Range of Products	
	No Process Improvement Action was found to be a strong link.

As a result of the descriptive analysis none of the Process Improvement Actions was considered to have strong links. Therefore none were ranked.

F3: Achieve Predictable Output	
K: Make people responsible for activities I: Standardise J: Error Proof H: Introduce case manager, worker or team	**K I J H**

There are no significant differences between K, I, J and H therefore they all appear on the same level.

F4: Reduce Changeover Time	
I: Standardise C. Eliminate non-value adding activities A: Reduce the number of activities in the process K: Make people responsible for activities B: Perform activities in parallel, not sequentially	

There is a significant difference between I and K, I and B, C and K and C and B but not between I and C or K and B. Therefore I and C sit on one level and K and B on a separate level. A is not significantly different from I, C, K or B so sits in the intermediate level between them.

F5: Reduce Bottlenecks	
C: Eliminate non-value adding activities	C ↑
L: Create alternative routes through a process	0.015 0.011 0.028 0.010 L
F: Re-sequence activities E: Move activities out of the process - to supplier B: Perform activities in parallel, not sequentially A: Reduce the number of activities in a process	F E B A ↓

There are significant differences between C and F, C and E, C and B and C and A but not between F, E, B and A themselves. Therefore C is included in the top level and F, B, E and A in the level below. L is not significantly different from C, F, E, B or A so sits in the intermediate level between them.

9.3 Discussion of results

This section summarises the results presented in section 9.2 in terms of the four performance dimensions of time, cost, quality and flexibility.

9.3.1 Time

Manufacturing lead-time and Cycle time have exactly the same rankings of Process Improvement Actions with *Eliminate non-value-adding activities* as the top level, *Reduce the number of activities within a process* at the intermediate level and *Perform activities in parallel rather than sequentially* at the lowest level.

Reducing the lead-time to make a product (which also appears in the flexibility category) only has one level that includes the three Process Improvement Actions above and also *Standardise*.

Davenport and Short (1990) and Harrington (1991) advocate the use of parallel rather than sequential activities for time reduction. They also suggest changing the sequence of activities and the reduction of movement in the process to reduce time. *Re-sequence activities* is suggested as a Process Improvement Action for reducing the distance travelled which is in itself is the equivalent of their suggestion to reduce movement.

Set-up time and Changeover time (which is included under flexibility) have the same set of Process Improvement Actions, ranked in the same order:

1. *Standardise*
2. *Eliminate non-value-adding activities*
3. *Reduce the number of activities within a process*
4. *Make the people or teams performing an activity responsible for it*

However Changeover time also includes *Perform activities in parallel rather than sequentially*. This was not included in the options for reducing Set-up Time as it had been removed as a result of the preliminary questionnaire.

Rework time and Inspection time are discussed with the results of the quality based Performance Requirements.

The results for the remaining performance requirements, Lead-time reliability and Output rate, were presented in the individual findings and will be presented again in the Practitioner Matrices presented in Chapter 10. These results offer new knowledge in that they indicate the Process Improvement Actions which when implemented should improve performance in that area.

9.3.2 Cost

The Process Improvement Actions favoured for the cost based Performance Requirements are *Reduce the number of activities*, *Eliminate non-value-adding activities*, *Standardise*, *Make the people or teams performing an activity responsible for it* and *Error Proof*.

Not all of the Process Improvement Actions apply to all of the Performance Requirements. The most notable exception is Cost of work in progress that does not include *Standardise*, *Make the people or teams performing an activity responsible for it* or *Error Proof*. Also Cost of material, Cost of inventory and Cost of scrap do not include *Reduce the number of activities within a process* or *Eliminate non-value-adding activities.*

Cost of rework, Cost of inspection and Cost of scrap will be discussed with the results of the quality based Performance Requirements.

9.3.3 Quality

Error Proof, *Standardise* and *Make the people or teams performing an activity responsible for it* appear together in 50% of the Performance Requirements and in 68 % of them one or a combination of them appear in the top level. They are the top three Process Improvement Actions suggested as having a strong effect on all of the Performance Requirements categorised under quality. They are also the top three in all of the quality-related questions that appear in the other Performance Requirement categories of the questionnaire; Reduce Rework time, Inspection time, Cost of rework, Cost of inspection and Cost of scrap. Finally they appear as the top three in achieving of Predictable output, increasing Lead-time reliability and reducing the Cost of materials.

Reduce defects per batch and Reduce non-conforming product, which are essentially the same Performance Requirement, resulted in exactly the same rankings of Process Improvement Actions. *Standardise, Error Proof and Make the people or teams performing an activity responsible for it* are at the top level and *Introduce a case manager, worker or team* at a separate level beneath.

Throughout the quality Performance Requirements the only other Process Improvement Action suggested is *Reduce the number of activities within a process.*

9.3.4 Flexibility

There were no Process Improvement Actions considered as having a strong enough effect on Increase range of products to appear in the rankings. When further consideration is given to the results of the descriptive statistics, the nearest Process Improvement Actions to inclusion are *Use IT or technology to enable activities* with a median of 4 and a mode of 3 and *Standardise* with a median of 3 but a mode of 5.

Increase range of products was defined as the ability of the 'Make Product' process to handle an increased Range of products. The questionnaire respondents did not consider that the implementation of any of the Process Improvement Actions suggested would improve the ability of the process to handle different products.

Changeover time and Lead-time to make product were discussed with the results for the time based Performance Requirements.

The results for the remaining Performance Requirements of Predictable output and Reduce bottlenecks were presented in the individual findings and will be presented again in the

Practitioner Matrices presented in Chapter 10. These results offer new knowledge in that they indicate the Process Improvement Actions which when implemented should improve performance in that area.

It is interesting to note however that reducing Bottlenecks is linked to more Process Improvement Actions than any of the other Performance Requirements. This includes *Create alternative routes or paths through a process,* the only time that this Process Improvement Action appears in the results.

9.4 General observations

This section discusses the results presented in section 9.2 in terms of the general patterns that can be observed and considers them in light of current business process re-design literature.

9.4.1 Redundant Process Improvement Actions

The Process Improvement Actions *Move activities out of the process - to the customer* and *Move activities into the process* do not appear in any of the rankings, as they did not emerge as strong links from the descriptive statistics.

The Process Improvement Action that involves the movement of activities such as inspection and purchasing back into the 'Make Product' process was suggested extensively throughout the business process re-design literature (Hammer 1990, Harrison and Pratt 1993, Ould 1995, Ballé 1995 and Armistead et al 1995). The questionnaire respondents did not see this as a strong Process Improvement Action.

It is not immediately apparent how moving activities back into a process can be beneficial, on the surface it would appear to add both time and cost to a process. Authors such as Hammer (1990) suggest that it is quicker, less bureaucratic and less costly to perform some activities in the process rather than having them performed by someone external to the process.

Move activities out of the process - to the customer was primarily drawn from the work of Jain et al (1994) and appeared to be an option with which the questionnaire respondents were not familiar or did not favour. Even faced with the idea they could not see the merit of getting the customer to do some of the work. Yet furniture, toys, white goods and many other products are sold in an unfinished state requiring the customer to complete the assembly.

9.4.2 Five popular Process Improvement Actions

The same Process Improvement Actions emerged as having a strong effect on a high proportion of the Performance Requirements. The most popular of these were *Standardise* at 75%, *Make the people or teams performing an activity responsible for it* at 72%, *Error Proof* and *Reduce the number of activities within a process* both at 60% and *Eliminate non-value adding activities* at 50%.

In all of the cases where *Standardise* appears in the rankings it is either at the top level (83%) or at the next intermediate level (17%). It is also included in all of the cases where there is only one level.

In all of the cases where *Error Proof* appears in the rankings it is either at the top level (68%) of at the next intermediate level (32%). It is also included in all but one of the cases where there is only one level.

Error Proof, *Reduce the number of activities within a process* and *Eliminate non-value adding activities* appear frequently though not necessarily at the top level and are spread throughout different Performance Requirements.

These five appear to be the popular Process Improvement Actions as the next most popular was only found to have a strong effect on 22% of the Performance Requirements. In fact out of the 126 instances of a Process Improvement Action having a strong effect on a Performance Requirement throughout the whole questionnaire the five popular Process Improvement Actions make up 80%. Therefore 80% of the possible changes can be achieved through the implementation of just five Process Improvement Actions.

The emergence of these five Process Improvement Actions as predominant within the questionnaire results could be due to the exposure of the respondents to the concepts. *Reduce the number of activities within a process* and *Eliminate non-value-adding activities* are suggested extensively through out the business process re-design literature by, amongst others, Edosomwan (1996), Ballé (1995), Hammer and Champy (1993) and Harrington (1991). This also applies to the Process Improvement Action *of Make the people or teams performing an activity responsible for it* (Hammer 1990, Ould 1995, Hammer and Champy 1993, Ballé 1995).

Error Proof is not mentioned as frequently in the business process re-design literature (Harrington 1991 and Edosomwan 1996) but is discussed in quality texts such as Shingo (1986) and Oakland (1993).

There is less support within texts for the inclusion of *Standardise* within these top five. Harrington (1991) suggests the standardisation of process documentation, procedures and activities so that everyone performs them in the same way.

9.4.3 Lack of Information Technology

The use of information technology to improve processes is suggested frequently through out the business process re-design literature (Hammer and Champy, 1993, Guha et al, 1993, Harrington, 1991). It is in fact the sole process improvement mechanism favoured by some authors (Davenport 1993). It is therefore interesting to note that it was not favoured by the questionnaire respondents, appearing only three times in the results.

9.5 Additional suggestions offered by respondents

The questionnaire also offered the opportunity for respondents to add additional suggestions of Process Improvement Actions that could, in their experience be implemented to improve each Performance Requirement.

In many cases the suggestions consisted of respondents qualifying some of their answers regarding a Process Improvement Action with a comment; either to support their opinion or to warn of a contextual issue that may impact on the strength of the improvement.

A majority of the other suggestions were considered to be outside the scope of the research and were classified into several groups. These are discussed below along with those suggestions that were not considered out of the research scope. A table showing the additional comments and their classification can be found in Appendix 8.

Strategic

Process Improvement Actions such as developing supplier-customer partnerships, affect more of an organisation than just the 'Make Product' process. The decision to implement such improvements must be made by the management of the organisation as a whole, therefore they are considered to be 'strategic'. The adoption of improvement philosophies such as lean manufacturing is also considered to be a strategic decision, rather than a change that can be made to a 'Make Product' process.

Management and operation of the process

There is a distinction to be made between the configuration of the 'Make Product' process undertaken during process re-design and the management and operation of that process. The aim of this research as outlined in Chapter 2 is to investigate the links between the Performance Requirements and Process Improvement Actions for the configuration of the 'Make Product' process. Many of the additional Process Improvement Actions added by respondents concern the management and operation of the process.

There were several popular suggestions; Statistical Process Control (SPC), Single Minute Exchange of Dies (SMED) and preventative maintenance all fall into this category.

The concept of one-piece flow was mentioned frequently, again this is involved with the management rather than the configuration of the process.

Involve processes other than 'Make Product'

Suggestions that do not apply to the 'Make Product' process alone or are technical in nature fall into this category. Several suggestions made were applicable to processes other than the 'Make Product' process, the most frequent of these being improved scheduling and forecasting. Better design of products and the use of concurrent engineering also fall into this category.

Measurement

In several instances measurement of a particular aspect of performance such as lead-time or supplier performance was suggested. These are not considered to be Process

Improvement Actions, as measurement in itself will not improve a process but rather the actions taken on the basis of the measurement feedback.

People

Training and development of employees is suggested several times, as are incentive schemes. These are seen as people management or Human Resources issues and are not included as Process Improvement Actions.

Justifiable additional suggestions

The Performance Requirement to Reduce distance travelled resulted in several alternative suggestions concerning the physical layout of the activities within the process. In hindsight this is unsurprising since the Performance Requirement is in itself concerned with a physical concept, distance. Concepts such as cellular manufacturing and the design of layouts for one touch handling are generally discussed in texts regarding workflow and factory layout but since the Process Improvement Actions used in this research were derived from business process re-design literature they were not included. They can be considered to be on the borderline of the scope of this research. As such their omission as Process Improvement Actions in this research is not a concern however they may merit further consideration in future extension or replications of this study.

Use IT or technology to enable activities was suggested as an additional Process Improvement Action for the improvement of Rework time, Labour productivity and Cost of labour. This was filtered out of the questionnaire in the preliminary stage but as it appears as an additional suggestion in several of the labour related Performance Requirements it may merit further consideration in future extension or replications of this study.

There are additional Process Improvement Actions suggested for specific questions:

- *Move activities out of the process - to the supplier* for Reduce inspection time
- *Error Proof* for Reduce set-up time
- *Error Proof* for Increase labour efficiency

Since these appear to be ad-hoc additional suggestions each supported by only one respondent they are not considered significantly important to warrant any further investigation.

9.6 Discussion

The findings of the individual questions form the links between Performance Requirements and the Process Improvement Actions that when implemented should improve performance. These will be used to populate the Practitioner Matrices to be presented in Chapter 10.

When the results were studied further some interesting observations emerge. These observations offer interesting research findings and also have implications for the Practitioner Matrices.

The results of the quality-based questions show the most agreement between questionnaire respondents. The same Process Improvement Actions are favoured for improvement in all areas of quality improvement, often in the same rank order. It is possible that the strength of agreement between respondents on the subject of quality is due to the exposure of the manufacturing industries to drives for quality improvement. Quality has been the focus of much manufacturing and improvement literature since the mid-1980's and the questionnaire respondents may well be more familiar with quality concepts than with those presented for time, cost or flexibility.

Thirteen Process Improvement Actions were included in the final questionnaire, yet the findings of this research indicate that a set of only five Process Improvement Actions is needed to achieve 80% of the Performance Requirements. These are; *Standardise, Make the people or teams performing an activity responsible for it, Error Proof, Reduce the number of activities within a process* and *Eliminate non-value-adding activities.*

This knowledge regarding the overall popularity of Process Improvement Actions is an extremely interesting result and has implications for business process re-design. Its contribution to the overall findings of this research is discussed in Chapter 11.

It is surprising that *Use IT or technology to enable activities* does not emerge more often as a preferred Process Improvement Action since that receives a lot of attention within business process re-design literature. The use of Information Technology for performance improvement was however offered as an additional suggestion by the questionnaire respondents for Rework time, Labour productivity, Cost of labour and Labour efficiency. It is possible that Information Technology would have been a more popular Process Improvement Action had it been offered in more of the Performance Requirements and not removed as a result of the preliminary questionnaire.

9.7 Conclusion

This chapter has presented the findings of the questionnaire used within this research to establish the links between Performance Requirements and Process Improvement Actions. The findings were presented showing the relative strength of the relationships between Performance Requirements and Process Improvement Actions so that a priority order could be given for the implementation of the Process Improvement Actions. The results of individual questions, popularity of Process Improvement Actions and emerging trends were then discussed.

The links between Performance Requirements and Process Improvement Actions that resulted from the questionnaire findings and that were presented in this chapter are used to populate the Practitioner Matrices to be presented in Chapter 10.

Chapter 10 - Development and validation of Practitioner Matrices and business process re-design approach

The first part of this chapter describes how the results of the statistical analysis presented in Chapter 9 were incorporated into a business process re-design approach suitable for practitioners. Written in the format of pages for a process-based change handbook this includes matrices containing the links between Performance Requirements and Process Improvement Actions, instructions for their use and supporting information regarding process thinking and the importance of having properly developed Performance Requirements. The handbook into which the pages are intended to fit is also introduced.

The second part of the chapter discusses the validation of the business process re-design approach with practitioners. It describes the development of a validation questionnaire, designed to validate the business process re-design approach and matrices in terms of both content and of relevance to the practitioner. Finally the results of the validation questionnaire are presented and discussed.

10.1 The business process re-design approach

10.1.1 Development of the Practitioner Matrices

The findings of the statistical analysis presented in Chapter 9 are not in a format considered appropriate for use by practitioners. Whilst the statistical analysis was required to ascertain and rank the strength of relationships between Performance Requirements and Process Improvement Actions details such as significance levels are not required by the practitioner. Practitioners merely need to know which of the Process Improvement Actions to consider for specific Performance Requirements and in what order they should consider them. The results of the statistical analysis should be presented in an appropriate, simple easily used format.

The format selected for the presentation of the results was that of a matrix. There is a matrix for each of the four performance dimensions, time, cost, quality and flexibility. These can be found in the validation material in Appendix 9. L shaped matrices were used as these allow for the comparison of two sets of items to each other (GOAL/QPC, 1994). The Practitioner Matrices have the Performance Requirements on the vertical axis and the Process Improvement Actions on the horizontal axis and the relationships between them shown in the matrix cells.

The statistical analysis resulted in a ranked list of Process Improvement Actions, with one, two or three levels, being suggested for each of the Performance Requirements. Icons (❶②③) in the relevant cell of the Performance Requirements row indicate the appropriate Process Improvement Actions, their level and thus the order in which they should be considered.

Throughout the questionnaire and the analysis the Performance Requirements have always been listed in the same order. This order was changed in the Practitioner Matrices with similar Performance Requirements for each dimension placed together making them easier to find on the matrices.

10.1.2 Use of the Matrices

It is possible that the Performance Requirement that the practitioner has may or may not appear on the matrices. Use of the matrices in both of these circumstances is discussed within this section.

Performance Requirement appears on matrices

The practitioner needs a Performance Requirement or preferably a set of strategically derived and balanced Performance Requirements before they can use the matrices. If the Performance Requirements that they have for their process appear on the matrices then identifying potential Process Improvement Actions is straightforward.

The practitioner need only decide if a Performance Requirement relates to time, cost quality or flexibility. They can then find it on the appropriate matrix and read along the row to find the Process Improvement Actions suggested. The order in which to consider the implementation of the Process Improvement Actions is indicated by the icon. Where several Process Improvement Actions are represented by the same number, they have been ranked level and can be considered to offer the same level of improvement as each other.

Each of the Process Improvement Actions can then be considered in turn (starting with the highest-ranking one) for applicability to the 'Make Product' process of the practitioner. The practitioner should consider which are the appropriate places within a process to implement the Process Improvement Action, how they might be implemented and if they are appropriate for the 'Make Product' process within the company. The order is not prescriptive, it is simply based on the opinions of an expert panel with 465 years of business process re-design expertise between them. The practitioner may choose not to implement the highest (number one) ranked Process Improvement Action and move on to consider the next one.

Detailed guidance is not given regarding how to implement the selected Process Improvement Action. To ensure that the practitioner has an understanding of what a Process Improvement Actions entails a definition of each is provided. Definitions of each of the Performance Requirements are also provided to facilitate the use of the matrix. These can be found in the validation material in Appendix 9.

Performance Requirement does not appear on matrices

Use of the matrices is more complex if the Performance Requirement that the practitioner has does not appear on them. In this case it should be checked that the Performance Requirement is a process-level measure applicable to the 'Make Product' process, for example profit is not a process-level measure. If the Performance Requirement is applicable it must be equated to a requirement that does appear in the matrices.

A table was drawn up that enables the practitioner to relate the performance requirement that they have to one that appears in the matrix. This can be found in the validation material in Appendix 9. This table lists the possible aspects of process performance for each of the four performance dimensions. The Performance Requirements that appears on the matrices relating to each of the aspects of performance are also given. The practitioner can then look up the Performance Requirement on the matrices to identify which Process Improvement Actions to consider. Implementing these Process Improvement Actions should improve the performance of the process with regard to the original Performance Requirement of the practitioner.

10.1.3 Delivering the business process re-design approach

The aim of this research as outlined in Chapter 2 was to investigate and establish links between Performance Requirements and Process Improvement Actions. These links would then be used in a business process re-design approach to select the appropriate Process Improvement Actions to implement to achieve the Performance Requirements.

Such links were established from the questionnaire findings discussed in Chapter 9 and are presented in the Practitioner Matrices.

These matrices are not intended to be used in isolation but as part of an overall business process re-design approach. They require the practitioner to have a strategically derived and balanced set of Performance Requirements to drive the selection of Process Improvement Actions and to understand the concept of process thinking and what is meant by the 'Make Product' process.

It is considered that an appropriate delivery mechanism for the matrices would be an established process-based change methodology. It is intended that the matrices be included within 'A Process-Based Change Handbook' (Childe et al, 2000a). This handbook was the main deliverable of an EPSRC research grant to develop a methodology for business process re-engineering within small and medium enterprises. The handbook was chosen as a vehicle to support the matrices as:

- It introduces the concept of process thinking, possible process architectures and of the 'Make Product' process.

- It outlines the role of performance measurement within process-based change.

- It contains tools and case studies that enable companies to develop the holistic, balanced and strategically derived Performance Requirements recommended prior to using the matrices.

- The handbook addresses other factors that may affect the success of the business process re-design such as human factors and also offers guidance on implementation of process change.

- The methodology was developed to be suitable for practitioners - simple, practical and user-led.

- The process-based change methodology and the material and tools it contains have been tested and validated thoroughly (Childe at al, 2000b).

10.1.4 The supporting information

The Practitioner Matrices and the instructions for their use are presented as additional pages that could be included in 'A Handbook for Process-based Change.' (Childe et al, 2000a). These pages also include some supporting information that summarises the concept of process thinking, the 'Make Product' process and the importance of strategically derived performance requirements, see Appendix 9. This supporting information is included for two reasons:

1. The Practitioner Matrices and their use in a business process re-design approach must be tested by thorough validation by practitioners. It is infeasible to send out the complete process-based change handbook so a summary of the underlying concepts is required to put the matrices into context for the practitioner.

2. Even if the practitioner were using the complete handbook the additional information reminds the practitioner of the underlying concepts before they use the matrices.

10.2 Validation of the research findings

As previously stated the research described within this thesis was exploratory in nature and investigated the feasibility of establishing links between Performance Requirements and Process Improvement Actions. These links could then be used in business process re-design to select the appropriate Process Improvement Actions to implement to achieve specific Performance Requirements.

The concept of establishing such links and using them for business process re-design is tested through the validation of the handbook pages described in the first part of this chapter. This validation is outlined in the remainder of this chapter.

The validation conducted was concerned with:

- *Whether the approach addresses the five needs of practitioners as identified by Thomas and Tymon (1982) outlined in section 2.6.8.2.*

This includes questions that cover

- *Whether the research questions have been answered.*
- *The concept of using the matrices in a business process re-design approach.*
- *Whether the approach addresses the weaknesses of existing business process re-design approaches outlined in Chapter 3 and the requirement for performance measurement as outlined in Chapter 4.*
- *The content of the Practitioner Matrices*

10.2.1 Validation questionnaire

In order to carry out the validation, copies of the handbook pages were sent out together with a questionnaire seeking the opinion of practitioners.

The questionnaire contained 26 closed questions designed to cover all areas of validation as set out in section 10.2. Answers were collected by way of a five point Likert scale ranging from strongly agree, through agree, neither, disagree to strongly disagree. Details of alternative scales, reasons for use and characteristics can be found in Chapter 7, which discusses the design of the main questionnaire. Questions were expressed in both positive and negative form to negate the possibility of the practitioners ticking straight down a column. Practitioners were also asked closed questions regarding their business process re-design experience. Finally they were offered the opportunity to make any general comments, comments regarding specific questions and any suggestions for improvement that they may have.

A copy of the questionnaire and summary of responses can be found in Appendix 10.

10.2.2 Information distributed to practitioners

The material for validation was sent to practitioners via e-mail. The covering e-mail provided an introduction to the material and the reason for validation as well as a reminder of the purpose of the research. The file sent to practitioners included:

- Supporting information outlining process thinking, the 'Make Product' process and performance measurement
- The Practitioner Matrices and instructions for their use
- Definitions of Process Improvement Actions and Performance Requirements
- The feedback questionnaire.

10.2.3 The practitioners who completed the validation questionnaire

The material for validation and feedback questionnaires was sent to practitioners who had volunteered to complete the original questionnaire. This was regardless of whether they had returned that questionnaire. It was considered that these practitioners would have the experience and knowledge required to complete the questionnaire.

Of the sixty practitioners approached for validation responses were received from fourteen. Of these, thirteen were from the thirty experts who had completed the original questionnaire.

10.3 Results of the validation

The feedback received from the practitioners was analysed and is presented in this section. It is discussed in terms of the content of the Practitioner Matrices and the five practitioners needs (Thomas and Tymon, 1982). The additional comments offered by practitioners were grouped into several specific issues and are also discussed.

10.3.1 Content (Questions 1-2)

The first two questions validated the content of the matrices. These asked the opinion of the practitioners regarding the correctness of the links established and the appropriateness of the Process Improvement Actions and Performance Requirements used.

All of those who completed the feedback questionnaire believed very strongly or strongly that the links were essentially correct and the variables used were appropriate. This gave the researcher confidence in the validity of the survey findings and so in presenting them in the process re-design approach as suggestions to the practitioner.

The Process Improvement Actions and Performance Requirements used in the questionnaire had also been validated through the testing of the preliminary and pilot questionnaire outlined in Chapter 7.

10.3.2 Practitioner needs

Descriptive relevance (Questions 10-11, 16-18, 24-25)

These questions were concerned with the relevance of the new knowledge to a practitioner when undertaking process re-design of the 'Make Product' process.

The practitioners were asked whether they thought that the approach could be used to address business process re-design of the 'Make Product' process in different companies. All of them agreed, some strongly, that the approach could be used in companies other than their own. Descriptive relevance is also reflected by the diversity of companies, in which the practitioners work and in which they believe the approach could be used. These include clothing, tyre, bicycle, automotive interior, consumer electronic and printed circuit board manufacturers besides consultancies.

The research is based on the premise that strategically balanced performance requirements are important in the re-design of the 'Make Product' process. There are several questions that cover this issue.

All of the practitioners strongly agreed that performance measures should be developed in line with the strategy of the organisation. They also all agreed, a majority strongly, that it is important to use strategically derived performance requirements when re-designing business processes.

There was not the same level of agreement when asked if it is important to have balanced performance requirements for the 'Make Product' process. Whilst a majority 86% agreed or strongly agreed with this, 7% had no opinion and 7% disagreed. The practitioner who disagreed gave no indication of his reasons. Whilst he believed that Performance Requirements should be strategically derived and that processes should be re-designed to meet specific Performance Requirements he did not see the necessity for them to be balanced.

It was also of importance whether the practitioners agreed that it is important to re-design business processes to achieve specific performance improvements. All of the practitioners believed this to be the case, 64% of them strongly.

When asked if it they considered it important to take a holistic view when re-designing business processes 93% agreed or strongly agree and 7% expressed no particular opinion.

Overall the fact that the Performance Requirements used should be strategically derived and balanced and that the process should be re-designed to meet specific Performance Requirements was strongly supported. The practitioners also supported the need for a *holistic approach to business process re-design.*

Goal relevance (Questions 7, 12-14, 19, 21-23)

These questions were concerned with whether the new knowledge generated would help companies in the re-design of a 'Make Product' process.

71% of the practitioners believed that using the business process re-design approach presented would improve their current business process re-design practices. The remaining 29% expressed no opinion. 93% said that they would use the approach when next re-designing a 'Make Product' process.

The practitioners considered the business process re-design approach to be a valid method for re-designing a 'Make Product' process and indicated that they would be willing to use it within their companies. The fact that a vast majority of the practitioners also believed that the approach would improve their current business process re-design activities indicates that they view it as a valuable new option now available to them when re-designing.

With regard to whether they believed that the approach would help to structure a business process re-design project 93% strongly agreed or agreed that it would, the others had no particular opinion.

All of the practitioners believed, some strongly, that the matrices could be used to trigger further ideas for process changes to make.

It was extremely important for goal relevance that the matrices developed should help practitioners in selecting the appropriate process improvement actions to implement when re-designing a 'Make product' process to achieve specific performance improvements. 93% of the practitioners believed that they would. Only 7% had no particular opinion.

71% of the practitioners agreed that the approach would encourage companies to consider the performance requirements of a 'Make Product' process throughout re-design. 21% had no opinion but 7% disagreed strongly. One practitioner did not believe that this aim was satisfied. The practitioner who disagreed gave no indication of his reasons. It is possible that whilst he agreed that the approach would help companies to select Process Improvement Actions on the basis of Performance Requirements he did not believe that this would encourage the consideration of Performance Requirements throughout the re-design project.

Finally, whether the approach would help in understanding the role of strategically derived performance measures within business process re-design was ascertained. 64% of the practitioners believed that it would, 29% had no opinion and 7% disagreed. The practitioner who disagreed gave no indication of any reasons. Use of the business process re-design approach in conjunction with the complete process-based change handbook would improve this and the role of strategically derived performance requirements would be explained more fully.

It would appear therefore that the business process re-design approach presented would help companies in the re-design of their 'Make Product' processes.

The practitioners believed that the matrices could be used for the selection of Process Improvement Actions and to trigger further re-design ideas. It was also agreed that the approach would help to structure a business process re-design project and would encourage companies to consider the Performance Requirements throughout re-design.

Operational validity (Questions 3-6, 8-9, 12, 15)

These questions were concerned with how easy the practitioner believed it would be to use the matrices and how well the practitioners understood how to use them.

Participants were asked about the ease of use and their understanding of the matrices when the specific Performance Requirement that they had appeared on the matrices and when it did not.

Overall a majority of the respondents strongly agreed or agreed that it would be easy to use the matrices when their specific Performance Requirement appeared on them and that the understood how to use them.

The response was less positive when the Performance Requirement did not appear on the matrices. As far as ease of use was concerned 43% believed that they were easy to use, 29% had no particular opinion and 28% did not think they would be easy to use. With regard to understanding how to use the matrices, the percentages were 57%, 21% and 21% respectively.

It is undoubtedly more complicated to use the matrices when the specific Performance Requirement that a practitioner has does not appear, so the Performance Requirement that they do have must be translated prior to using the matrices. It is possible that using the matrices in such instances could be made easier by improving the instructions for translating Performance Requirements. The problem could also be reduced by the inclusion of more Performance Requirements in the matrices. This was not considered feasible in this research and is discussed in Chapter 11.

When general use of the approach is considered, 71% thought that they would have no difficulties using it and 29% had no particular opinion.

With regard to whether the practitioners would find the selection of process changes easy using this approach a majority 76% believed it would be, 7% had no opinion and 7% did not think it would be easy. The practitioner who disagreed gave no indication of their reasons though they did believe that the matrices could be used to help in the selection of Process Improvement Actions to meet specific Performance Requirements.

The majority of the practitioners understood the matrices and believed that they would be easy to use.

The remaining questions regarding operational validity were concerned with the supporting information. A majority, 79%, believed that there was sufficient supporting information to understand the context of the approach, 7% had no particular opinion and 14% did not think that there was sufficient supporting information. The practitioners who did not believe that there was sufficient supporting information gave no indication of their reasons. Use of the business process re-design approach in conjunction with the complete process-based change handbook could be expected to improve this.

If the practitioners' understanding of business processes in particular is considered 93% said that they understood the concept and 7% expressed no particular opinion.

The majority of the practitioners believed that the supporting information was sufficient to understand the context of the business process re-design approach and the concept of business processes.

Non-obviousness (Question 26)

To ascertain if the findings of the research offered new knowledge to the practitioner and were more than 'common sense' they were asked if they had seen the links between Performance Requirements and Process Improvement Actions for the 'Make Product' process established and stated elsewhere. Surprisingly 63% believed that they had. Some of these said where they had seen the links and these are discussed later in this section. The five practitioners who did not say where they had seen it were sent an e-mail asking them to say where. Unfortunately the response to these was disappointing. Only two replied; one had not in actual fact seen links established before but always tried to link Performance Requirements and Process Improvement Actions himself when promoting the merits of a business process re-design project. A similar answer was received from another of the practitioners who stated that the links between Performance Requirements and process improvements should be reflected in the company's strategy and business plans and specified within the action plans to achieve these. The Practitioner Matrices would give them a mechanism to do this.

The three who did not respond to the request for explanation pose a problem to the researcher. Without knowing where the practitioner saw the links established the researcher could not assess the similarities between them and the research presented in this thesis. It is assumed that their opinions are reflected in the opinions of those who did answer.

Three (21%) of the practitioners actually stated where they had seen the links between Performance Requirements and Process Improvement Actions for the 'Make Product' process established and stated before. These included:

'*....the Toyota Production Methods Time Based Management*'

'*...publications on Lean Manufacturing*'

'. ..*books by Schonberger on World Class Manufacturing*'

'....*The New Manufacturing Challenge – Suzaki*....'

'....*The New Performance Challenge – Dixon*....'

These sources were re-examined. Dixon at al (1990) stress the relationships between and importance of linking strategy, performance measures and actions within their work. No links between specific Performance Requirements and Process Improvement Actions are stated though some are alluded to in the discussion of flexibility and its measurement.

Lean Thinking was included in both the theoretical and empirical investigations of business process re-design approaches presented in Chapter 3. The focus of Lean Thinking is on the reduction of waste primarily through the identification and elimination of non-value-adding activities. In the classic 'Lean Thinking' text, Womack and Jones (1996) state that companies should '....*rethink specific work practices to eliminate backflows, scrap*...' etc. They do not specifically link these to Process Improvement Actions. They do discuss Process Improvement Actions including one piece flow, Just in Time, Poka-Yoke (Error Proofing), standardisation and line balancing with regard to the general reduction of waste, but do not address the issue of matching actions to Performance Requirements or of selection priorities.

Schonberger (1986) and Suzaki (1987) both discuss the use of Japanese manufacturing techniques to improve manufacturing activities. These were not included in the original literature review, as they are not considered to be business process re-design approaches as defined in this research and outlined in Chapter 3. They contain techniques to improve manufacturing activities towards world class manufacturing levels. These include Poka-Yoke, set-up reduction, physical layout changes, product flow, Kanban and operator training. The Performance Requirements used by these authors are not strategically driven but focus generally on the improvement of quality, cost, lead-time and flexibility

(Schonberger, 1986) and the reduction of waste (Suzaki, 1987) within manufacturing. There is some breakdown of these into more detailed measures, such as set-up time but the treatment is minimal.

It is acknowledged that Schonberger (1986) and Suzaki (1987) do discuss some of the Performance Requirement and Process Improvement Action links for the 'Make Product' process. With the exception of lead-time these tend to be at the generic level of cost, quality and flexibility and many of the suggested Process Improvement Actions are technical in nature.

The 'Toyota Production System' (Monden 1998) adopts many of the same techniques as Schonberger (1986) and Suzaki (1987) such as Kanban, Just in Time, process layouts and operator training as well as the reduction of waste. Time Based Management is specifically concerned with the reduction of Takt time (units per hour to meet customer demand), line balancing, Kanban and Just in Time.

Schonberger (1986), Suzaki (1987), Womack and Jones (1996) and Monden (1998) do, in varying degrees discuss the links between Performance Requirements and Process Improvement Actions. The Performance Requirements tend to be more generic than those in this research, and are not strategically derived. Many of the Process Improvement Actions are more technical in nature. The links are not clearly stated and which Process Improvement Action to implement is not easily found. Schonberger (1986), Suzaki (1987) and Monden (1998) do not have a process focus and improvements are made to manufacturing activities, not part of a business process re-design approach.

The perceived similarities between the links established within this thesis and Japanese Manufacturing techniques may occur due to the focus of the research being on the 'Make

Product' process. This will be discussed further in Chapter 11.

Timeliness (Question 20)

To ascertain whether the results of the research are being made available to practitioners at the time they are required, practitioners were asked if they were currently undertaking a business process re-design of their 'Make Product' process. Only 28% said that they were currently undertaking business process re-design of the 'Make Product' process, 43% said that they were not. However if asked the less specific questions of whether they were undertaking any business process re-design projects at the presented time 79% said that they were.

The undertaking of business process re-design projects and continuous improvement is generally prevalent in companies.

10.3.3 Practitioner comments

The questionnaire contained three open questions in which the practitioners could offer general comments, comments regarding specific questions and suggestions for improvements. None of the practitioners made comments regarding particular questions. The remaining comments were grouped into several common issues and are discussed in this section.

Scope

The practitioners expressed some concern regarding the limitation of the approach to the 'Make Product' process. One in particular did not agree with this, another suggested that the effects of design changes should be considered (his specialist area was configuration management).

This is acknowledged however limiting the scope to the 'Make Product' process was required to put a boundary around the research as explained in Chapter 2. The implications of this decision to the research are debated in Chapter 11.

Improvements to supporting information

Several of the participants suggested the definitions included to help the practitioner in deciding which Process Improvement Action to implement and what each of them entailed could be more detailed, for example the inclusion of more examples of non-value-adding activities.

One also suggested relating some of the statements to accepted models. This was not done in the supporting information sent for validation, but such links are made in the complete Handbook of Process-Based Change (Childe et al , 2000a).

Making business process re-design work

Practitioners suggested actions that could contribute to the overall success of a business process re-design project. These included early involvement of the workforce, detailed strategic objectives, detailed plans, simple measures and facilitation.

The researcher agrees that such actions could improve the success of a process re-design project. It is for that reason that the matrices were developed for inclusion in an existing process-based change methodology. The supporting information itself does outline strategic objectives and performance measures. The handbook deals with human factors, implementation planning, derivation of measures and strategies etc.

The Process Improvement Actions and Performance Requirements included

One of the practitioners suggested that the reduction of lot sizes should be included in the matrices. He also suggested this when completing the original questionnaire and it is discussed in Chapter 9.

The same practitioner also questioned some of the Performance Requirements, particularly Cost of work in progress and inventory. The choice of Performance Requirements was outlined in Chapter 6 and will be debated further in Chapter 11.

It was just one practitioner who made these comments. Generally the Performance Requirements and Process Improvement Actions were believed to be a reasonable representation of the 'Make Product' process.

General comments

Overall the practitioner comments were positive, with a number of them commenting on the usefulness of such research to practitioners and on the material presented. These comments included:

- *'I consider this kind of research is important to compare ...with some theories found in books, because sometimes it is not a good approximation of our reality'*
- *'....very scholarly and quite sound...'*
- *'Very informative...a roadmap on how to approach the subject'*
- *'I'll use it in my next projects'*
- *'....the structured approach whereby different actions are prescribed for different courses of action is novel.'*

10.4 Conclusion

The first part of this chapter outlined the development of a business process re-design approach in the form of handbook pages. These are to be included in an existing process-based change handbook that outlines a complete methodology for business process re-engineering. The handbook pages include matrices containing the links between

Performance Requirements and Process Improvement Actions, instructions for their use and supporting information to place them in context and offer a business process re-design approach. The second part of the chapter explained how this material was validated with practitioners through a feedback questionnaire. The results of this validation were positive overall and were presented in terms of content and practitioner needs. Some specific issues arose, which will be discussed in Chapter 11.

Chapter 11 - Conclusion

This final chapter begins by considering whether the research presented within this thesis has answered the research questions posed and what those answers are. These are addressed in detail in the description of the contribution to knowledge claimed by the research. A critical review is then included of some of the decisions made whilst undertaking the research. Finally, future areas of research are presented and some final observations and conclusions discussed.

11.1 The research questions answered

Three key research questions were formulated to focus this research. The answers to those questions are briefly outlined within this section. A more detailed account of the answers can be found in section 11.2 discussing the contribution to knowledge of this research.

1. *Is it possible to identify and characterise a set of generic Process Improvement Actions?*

- Yes, a set of generic Process Improvement Actions was derived from existing process improvement, business process re-design and business process re-engineering literature as described in Chapter 5.

2. *Can individual improvement actions be linked to specific performance improvements and what are those relationships?*

- Yes, the consensus amongst questionnaire respondents showed that individual improvement actions could be linked to specific performance improvements. The links established as a result of statistical analysis of the questionnaire data were detailed in Chapter 9.

3. *If such links can be established is it possible to use them to direct appropriate actions in process re-design, to achieve the performance targets set for the process?*

- Yes, the links established were presented in the Practitioner Matrices and incorporated into a business process re-design approach. This was validated with practitioners whose views were favourable regarding use.

11.2 Contribution to knowledge

The research presented within this thesis contributes both to existing knowledge and to practice. These contributions are outlined within this section.

Generic Process Improvement Actions

Chapter 5 resulted in a list of generic Process Improvement Actions derived from literature within the field of business process re-engineering, business process re-design and process improvement. There are many re-design principles and guidelines suggested throughout this literature with different authors giving different names to what is, in actual fact, the same recommendation. The generic list brings all of the suggestions together and proposes one list of common Process Improvement Actions applicable to the 'Make Product' process.

The generic Process Improvement Actions were validated twice within the research, as variables within the preliminary testing of the questionnaire as outlined in Chapter 7 and again in the validation of the Practitioner Matrices outlined in Chapter 10.

The Performance Requirements

Chapter 6 resulted in a list of Performance Requirements derived from performance measurement literature. The Performance Requirements are applicable specifically to the 'Make Product' process and are ones where changes made to the 'Make Product' process alone contribute to performance.

The Performance Requirements were validated twice within the research, as variables within the preliminary testing of the questionnaire as outlined in Chapter 7 and again in the validation of the Practitioner Matrices outlined in Chapter 10.

Encourages the use of strategic Performance Requirements in business process re-design

The proposed business process re-design approach encourages practitioners to use strategic Performance Requirements when re-designing.

The Practitioner Matrices necessitate the development of Performance Requirements for the process; otherwise they cannot be used. The information that surrounds the matrices to form the business process re-design approach advocates that these Performance Requirements be developed in line with the key characteristics of performance measurements as outlined in Chapter 4. The handbook for process-based change offers guidance on how to do this.

The importance of using strategically derived and balanced Performance Requirements when re-designing the 'Make Product' process was supported through the validation of the Practitioner Matrices and the business process re-design approach outlined in Chapter 10.

Ensures focus on strategy throughout business process re-design

Use of the Practitioners Matrices in business process re-design for the selection of Process Improvement Actions ensures that strategic requirements and thus strategy are considered throughout the re-design activities.

As discussed in Chapter 3, current business process re-design approaches commonly suggest that Performance Requirements should be derived from the strategy of the organisation or change programme and the existing 'as-is' process be measured using these to gain a benchmark performance level. Once implemented the new process is measured to ascertain the improvements made. However in current approaches these strategically derived performance measures do not appear to play a role in the re-design of the process.

The use of strategically derived Performance Requirements in the Practitioner Matrices as the driver to select Process Improvement Actions ensures that they are considered during the re-design.

When validated the majority of practitioners agreed that using this approach to business process re-design would encourage companies to consider the Performance Requirements throughout re-design.

Indicates the actions to take in priority order

The business process re-design literature review outlined in Chapter 3 highlighted the fact that existing business process re-engineering and re-design approaches offer only limited guidance on the specific changes that can be made to a process when re-designing it.

This research resulted in a list of the Process Improvement Actions to be considered for each of the specific Performance Requirements. These are ranked from the one offering the most improvement to the one offering the least improvement, indicating the order in which they should be considered.

These lists enable the practitioner to immediately identify appropriate Process Improvement Actions and the suggested order of implementation.

Practitioners agreed that the suggested Process Improvement Actions and their priority order were essentially correct and that having such lists would be useful to them.

Sets the agenda for the intervention

Since the possible Process Improvement Actions are known for each of the Performance Requirements the practitioner can set the agenda for the interventions he is going to make: he can select Process Improvement Actions on the basis of his Performance Requirements.

This enables the process re-design to be tailored to meet the improvements required rather than attempting to identify and eliminate all weaknesses or undertake generic improvements as advocated by many existing business process re-design approaches.

All but one of the practitioners agreed that the research, through the Practitioner Matrices, enables the selection of Process Improvement Actions on the basis of Performance Requirements.

Links can be established between Performance Requirements and Process Improvement Actions

Key to this research was the question of whether links could be established between Performance Requirements and Process Improvement Actions. The findings of the research show that it is possible to establish such links.

The links were established through the use of a questionnaire distributed to a sample of business process re-design experts from industry. The consensus in results amongst the practitioners enabled the strong links between Performance Requirements and Process Improvement Actions to be drawn out from all of the combinations offered and for these to be statistically analysed and ranked where significance allowed.

The links established were validated with practitioners as outlined in Chapter 10.

The links established can be used in business process re-design

Also key to this research was the question of whether the links established between Performance Requirements and Process Improvement Actions could be used in practice. The findings of the research show that this is possible.

The links established were presented in the Practitioner Matrices and incorporated into an approach for business process re-design. The Practitioner Matrices and the approach were validated with practitioners who agreed unanimously that they would help them to select Process Improvement Actions to meet their Performance Requirements, that they would use such an approach and that it would improve their current re-design practices.

The Practitioner Matrices and their presentation give structure to business process re-design activities

The case studies outlined in Chapter 3 indicated that some companies approached business process re-design in an unstructured and ad-hoc way. The Practitioner Matrices present the links between Performance Requirements and Process Improvement Actions in a clear and structured way appropriate for the practitioner. This allows easy selection of Process Improvement Actions. 93% of the practitioners who validated the research agreed that using the Practitioner Matrices in a business process re-design approach would add structure to re-design activities.

The Practitioner Matrices can be used to trigger creativity

The Practitioner Matrices are used to identify possible Process Improvement Actions and therefore can be used as a mechanism to kick start process re-design and trigger further ideas as to process changes to make. The practitioners who validated the research all agreed that using the matrices in a business process re-design approach could trigger ideas for possible process re-design options.

Five key Process Improvement Actions

The findings of the questionnaire analysis showed that 80% of the suggested changes could be achieved through the implementation of just five Process Improvement Actions. These are *Standardise*, *Make people or teams performing an activity responsible for it*, *Error Proof*, *Reduce the number of activities within a process* and *Eliminate non-value-adding activities*. This finding has implications both for research and for practice.

There are many Process Improvement Actions suggested throughout business process re-design literature, from which a list of thirteen generic Process Improvement Actions was derived, as presented in Chapter 5. This literature does not however make any suggestions that only a sub-set of these, i.e. the five popular Process Improvement Actions need be considered to offer performance benefits in a majority of cases.

With regard to practitioners, rather than having to consider all of the thirteen generic Process Improvement Actions companies could, in the first instance, consider just the reduced set of five. Though this would limit the choice given to companies it has the potential not just to simplify, but to quicken business process re-design activities.

11.3 A critical review of the research

It became apparent when compiling the Practitioner Matrices the degree to which earlier decisions regarding the scope of the research affected the outcome. In order to delineate the research it focused on only one process, the 'Make Product' process as discussed in Chapter 2. Whilst this was necessary for the research it has implications for the relevance of the research to the practitioner. The 'Make Product' process does not operate in isolation within companies, for example it is provided with schedules from the 'Plan Order Fulfilment' process and product designs and specifications from the 'Develop Product' process. These other processes can therefore affect the performance of the 'Make Product' process, an issue raised by some of the practitioners in the validation questionnaire. It is acknowledged that there are other processes that influence the performance of the 'Make Product' process and that they may also affect the success of some of the Process Improvement Actions suggested in this research. The main aim of this research was however to test whether links between Performance Requirements and Process Improvement Actions could be established and used in business process re-design. The research showed that establishing and using such links is possible. Extending the scope of the research to the 'Order Fulfilment' process in order to address the scope limitations outlined above will be discussed as future research in section 11.4.

The selection of the 'Make Product' process as the focus of the research highlighted similarities with concepts such as World Class Manufacturing and the adoption of Japanese Manufacturing Techniques. Such concepts are not process-focused or strategically driven and aim to improve the performance of a company's manufacturing activities generically. In such they share some of the weaknesses seen in existing incremental business process re-design approaches. They do however offer some improvement suggestions akin to those included in the Process Improvement Actions of this research. Since the Process Improvement Actions used in this research were derived from business process re-design literature they are not included. They can be considered to be on the borderline of the scope of this research. As such their omission as Process Improvement Actions in this research is not a concern, however they may merit further consideration in future research or in any replications of this study.

The issues introduced as a result of the limitation to the 'Make Product' process do not affect the overall findings of this research and addressing of the research questions. The research was exploratory, testing the concept of establishing and using the links between

Performance Requirements and Process Improvement Actions, which has been shown to be possible. The issues identified regarding scope can be used to inform any future research that operationalises the concept tested in this research.

Performance Requirements were also selected to be within the scope of the research and also to meet particular characteristics. The Performance Requirements selected were not just those typical to the 'Make Product' process but those over which the process had the control to make improvements. This meant that some common Performance Requirements were not included in the Practitioner Matrices. Rules for translating these Performance Requirements into ones that did appear on the matrices were required. This complicated the use of the Practitioner Matrices in those circumstances. In hindsight it may have being better to derive a list of typical Performance Requirements for the 'Make Product' process, though this would probably have led to an even larger questionnaire and its attendant difficulties, which the researcher was keen to avoid.

As with the scope issues discussed within this section, any issues with the selection of Performance Requirements do not affect overall findings of this research and addressing of the research questions.

11.4 Future research

This research has shown that the relationships between process changes and the performance improvements gained from implementing them can be established on the basis of the experience and knowledge of business process re-design experts in industry. It also showed that it is possible to use these relationships in a business process re-design approach that is of use to practitioners when re-designing processes and that it addresses some of the weaknesses of existing business process re-design approaches. This was exploratory research on a limited scale concerned with the possibility of establishing and using the relationships. It was not concerned with establishing a comprehensive set of Performance Requirement to Process Improvement Action links for all processes nor a complete business process re-design approach.

There are two main areas of future research: conducting full-scale research to establish a more comprehensive set of Performance Requirements to Process Improvement Action links and extending the scope of the research.

At the core of this research are the relationships between Performance Requirements and Process Improvement Actions. These were established in this research to show that establishing such links was possible and that they could be used in business process re-design.

Future research could be undertaken to establish a more comprehensive set of links including Performance Requirements and Process Improvement Actions omitted from this research as discussed in section 11.3. The actual aim of this future research would be to establish the links and so it should include a full-scale survey with a larger sample of process re-design experts than used in this research. The larger sample would increase the validity of the survey results and reduce the possibility of errors due to the sample or the statistical conclusions inferred from the data.

The concept of establishing links between process changes and improvements could be applied to other processes. In some cases this may entail the undertaking of further exploratory work to test that it is possible to make such links within that process, for example to the 'Develop Product' process. Other processes such as the 'Plan Order Fulfilment' process for which practitioners have suggested possible Process Improvement

Actions during this research may be immediately subjected to full-scale research to establish the links.

The processes discussed are all part of the overall 'Order Fulfilment' process as shown in Chapter 2. This can be defined as an 'Operate' process. It may also be possible to extend the work to other types of processes such as 'Support' processes or even to other industries. In such cases it would be advisable to undertake small-scale exploratory work such as that outlined in this research prior to any full-scale research to check that links between Performance Requirements and Process Improvement Actions can be established and used.

11.5 Concluding observations

The researcher had no preconceived view as to whether it would be possible to establish links between Performance Requirements and Process Improvement Actions at the start of this research. She thought that the plethora of contextual issues surrounding business process re-design may prevent there from being any consensus on the improvements available for specific process changes. However she was also of the opinion that once at the level of the 'Make Product' process there must be some general relationships to be established.

The discovery that despite all of the contextual concerns regarding business process re-design it is still possible to establish and rank possible Process Improvement Actions suitable for Performance Requirements appealed to the researcher. Whilst these may have various degrees of success in different companies due to the implementation and contextual issues the links can still be used. They can direct the re-design activities and help to overcome some of the difficulties encountered by companies when re-designing their processes.

The results of the questionnaire analysis showed some interesting trends that did not contribute directly to the aims of this research or in answering the research questions. The researcher found the strength of consensus regarding quality and quality-related Performance Requirements and Process Improvement Actions very interesting. The top three Process Improvement Actions for all of these requirements were *Error Proof, Standardise* and *Make the people or teams performing an activity responsible for it,* often ranked in this order. The reason for this can only be speculated upon without further research. Quality improvement, from the early days of quality gurus through Total Quality Management in the 1980's, ISO 9000 Quality Standards and the European Foundation for Quality Management Excellence Model, has for many years being high on the agenda within many companies. Is it the exposure to this and associated attempts to improve quality that has united process re-design experts in their views of how to improve quality?

It was seen in Chapter 9 that just five Process Improvement Actions accounted for 80% of the strong links established; *Standardise, Make the people or teams performing an activity responsible for it, Error Proof, Reduce the number of activities within a process* and *Eliminate non-value-adding activities.* It would appear that in a majority of cases that improving performance of the 'Make Product' process could be achieved by implementing five basic Process Improvement Actions. Perhaps the true recommendation of this research should be that whatever strategic Performance Requirements a company wants to achieve, they should *Standardise, Make the people or teams performing an activity responsible for it, Error Proof, Reduce the number of activities within a process* and *Eliminate non-value adding activities.* Another area of future research, perhaps?

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3. Small manufacturing special interest group (SM)

- www.jiscmail.ac.uk/lists.html

1. Business process management (BPM)

2. Computer aided production management (CAPM)

Appendix 1

Case A – A major business process re-engineering project

Case A - A major business process re-engineering project

Overview

Company A is a division of a large British organisation. It operates as a stand-alone company within the organisation. The company undertakes the design, development, manufacture, testing and support of electronic, electromechanical and software products for both the civil and defence markets. The site has approximately 700 employees.

This case describes a major business process re-engineering project that was undertaken within that company by a dedicated Improvement Team made up from company personnel and external consultants. The researcher had frequent access to this team.

The information used to form the case was collected through observation of the re-engineering process by the researcher, discussions with the personnel involved and written documentation generated by the Improvement Team.

The project

The project was initiated as a result of a meeting of the company Management Committee in October 1997. The meeting had been called to discuss the performance of the company in that year, up to the date of the meeting. Performance had been disappointing with a considerable deficit in the orders received against the orders anticipated and disappointing profits.

The contributory factors to these disappointing results were believed to be:

- Falling customer satisfaction
- Reducing margins
- Lower order book/intake - some products just would not sell, some were sold at a loss
- Unfocussed
- Low morale
- Implementation of previous change had not been delivered
- The company was not effective or efficient in its operations

To address the situation the Management Committee decided to form an Improvement Team. This team was to be led by the Director of Sales and Commercial. In the meantime his role would be taken over by the Managing Director.

The brief of the team was to:

- Look at the processes used within the company and eliminate non-value-added activities
- Look at the product portfolio of the company, analysing which did not sell, which made losses and which were the most profitable best sellers

This was also to include the distribution of labour, management reporting, product sales/profitability and company culture and planning.

The team was to look at the processes within the company, liase with other areas and present their recommendations to the Management Committee within 90 days. Their aim: to recoup substantial losses by the end of 1998.

The main activities

Identification of problem areas and weaknesses

The Improvement Team began by collecting information regarding the processes and activities being undertaken within the company. This was used to map the processes, showing activities, people involved and time scales. Information regarding perceived weaknesses within the processes was also collected.

Each of the activities appearing on a process map were categorised as being:

- Core activities - the activities that a group exist to do / are core to producing an output
- Support activities - essential activities that must be performed for the core activity to take place
- Diversionary activities - activities carried out when a process failure has occurred

The activities were also defined in terms of their frequency, responsiveness, accuracy, timeliness and completeness.

Whilst the team were collecting the information required for the process maps they also noted any ideas and issues mentioned by those being interviewed. These were written on post-its and placed at the appropriate point on the process map. The issues considered key were those that affected the most people or had the most potential for cost saving. This information was used to help in deciding the key problems of the organisation derived after the functional walkthroughs.

Once all of this information was collected and process maps completed functional and process walkthroughs were undertaken.

The functional walkthroughs conducted by a member of the Improvement Team entailed working through the identified activities and asking:

- Why are we doing this? What value is added? What drives it?
- What performance levels are needed? What us the best method?
- If only.....would happen.....we could get rid of .....which is a diversionary activity?

The 'process walkthroughs' again conducted by a member of the Improvement Team entailed working through the processes and asking:

- What would the customer think? How is value added? Where is value eroded?
- What are the root causes of diversionary activities? What drives volume of activity?
- What are the sequences and location of activities?

The process maps and the information collected from the functional and process walkthroughs was used to identify the key problems faced by the company. These included:

- Weak strategy, too many products and markets
- Too bureaucratic, too many departments, approvals
- Not customer focussed
- No process
- High waste
- Inefficient collection of cost information

Addressing the weaknesses

The Improvement Team put cases together for several alternative solutions, which included an assessment of benefits, risks and feasibility. The alternative solutions were presented to the Management Committee who had the ultimate say in the way forward.

As a result of this review it was decided that the key activities to take place would include:

- A review of and better communication of the strategy of the organisation
- A review of the product portfolio
- A complete re-design of the organisation resulting in a process-based organisation structured as Value Chains

A majority of the activity within the project from this point forward revolved around the re-design of the organisation. The high level re-design of the organisation was to be conducted by the Improvement Team and the design of the Value Chains and processes by the teams themselves.

To focus this re-design activity desired characteristics for the new organisation and Value Chains were developed. Namely that:

The new organisation should:

- Have a clear unified strategy owned by the workforce
- Focus the whole of site to customers in a way understood by workforce
- Have a structured set of performance measures owned by the groups carrying out the processes. They should also understand the process and the levers of change
- The stakeholders and customers should be delighted by the outputs
- The processes within the company should meet their committed value plans or give enough warning for the overall company to manage a successful solution

The Value Chains should:

- Ensure that their value added is sustainable and in line with strategic agreements
- Have critical success factors identified and continually improved through the use of performance measures
- Negotiate performance levels with the other processes that they work

There were several possible ways of cutting the existing organisation in order to decide upon the appropriate Value Chains i.e. common products, capabilities, customers. It was decided to develop Value Chains based on common product functionality and purpose. Activities required to support these chains were split out and placed in a support chain and activities that served them all, such as precision machining placed in an in-feed value chain.

Development of critical success factors and performance measures

The Improvement Team also identified the development of performance measures as being important. The top level performance measures were to be developed by the Improvement Team and Value Chain performance measures were to be developed by the Value Chains themselves.

The Improvement Team generated a list of characteristics for successful performance measures:

- There should be good reasons for their use
- They should be the right ones
- They should be in support of the Value Plan – in line with strategy

- They should be visible, owned, dynamic, appropriate, the right number, the right level and should work together to give balance
- The Balanced Scorecard was the suggested method for the development of Performance Measures

Despite the promising ground work performance measures were not developed for the top level of the company until well after the new organisation had been designed. The action to develop them remained written on a 'To-do' list in the project room. This delay was exacerbated by a delay in the generation of a new strategy for the organisation.

Once the overall company had been designed and Value Chains established Value Chain performance measures were developed. Some of the Value Chains were more successful at this than others. On the whole they had designed and implemented the Value Chain prior to developing any measures.

The design of individual Value Chains

Each of the Value Chains was allocated a dedicated person to drive and champion the change, a Change Agent. They were responsible for helping the members of the Value Chains to design their processes and cells.

The principles underlying the design of the Value Chains within the organisation were Lean Principles and World Class Manufacturing Principles.

Lean principles

The principles of Lean Thinking were advocated by the Improvement Team and many of those involved in the re-design of the organisation and Value Chains were given a copy of 'Lean Thinking' (Womak and Jones, 1996). The Lean Thinking principles encouraged a focus on the elimination of waste within the organisation and the re-design activities. They are:

Value – defined by a customer for a specific product

Value stream – all the activities required to deliver a specific product

Flow – continuous flow of value stream (physical, information and control)

Pull – let customers pull value through

Perfection – benchmarking performance

World Class Manufacturing principles

The Improvement Team also advocated the principles of World Class Manufacturing which encourages the design of processes and cell with balanced aims:

Customer requirements 100% satisfied

Process identified, under control and adhered to

Performance improving

Supplier partnership managed

Teamwork, take ownership for performance and decisions

The Improvement Team developed a generic process for the design of Value Chains. This was presented as a rather thick document the contents of which appeared to outline an extremely long and complicated design method. The actual approach taken by each Value Chain tended to be a simplified version of this and was different for each Value Chain depending on that preferred by the Change Agent and members of the chain.

The re-design of Value Chains

The support value chain began by producing process maps of the activities that they undertook. They then studied the maps to identify:

- Customer Requirements
- Where they were complex
- Where they were inefficient
- Fundamental pathologies
- Streamlining possibilities
- Where activities could be joined together or moved out of the process etc.

No formal performance measures or targets were developed prior to re-design. These were developed once the Value Chain had been designed and implemented. The generic Value Chain design method did not suggest when performance measures should be developed.

The design of a Value Stream (a sub-process within the Value Chain)

The process being re-designed included design, production planning, purchasing and manufacture. Re-design activities began in March 1999 and were run by the Process Leaders and the Change Agent. This process was a supplier all of the Value Chains responsible for delivering product to customers.

Re-design approach adopted

At the level of the 'Order Fulfilment' process the World Class Model was used to encourage design of processes and cells to achieve performance in terms of what was referred to as the **ORPIWI** model:

Achieve **output** goals – quantity, quality, on time
Cost effective use of **resources** – people, equipment, resources
Manage the **process** – add value build in quality, schedule
Mange the **input** – materials, information, work with suppliers
Lead the **workgroup** – plan, organise, feedback, involve
Improve performance – customer requirements, beat competitors

The Lean Thinking principles encouraged the maximisation of value and minimisation of waste.

The Change Agent and Process Leader dictated the actual approach taken to the re-design of the process; the team conducted the re-design themselves.

The initial meeting

The re-design of the Value Stream process began with an away day involving the whole team. The purpose of the away day was to introduce the team to the principle of processes, Lean Thinking and World Class Manufacturing and to begin the re-design.
The principles of Lean Thinking were outlined and Lean Thinking introduced as cutting costs whilst maintaining quality, reducing lead-times etc. This comment led to some contention as to whether cutting cost was as important as some of the 'whilst' things listed. Cutting cost did come across as being the focus for re-design at that point

The concept of waste was introduced next and the team brainstormed what constituted waste within their current activities. The process re-design and improvement at this stage seemed to concentrate on the elimination of wasteful activity as a driver. This reinforced the view that the re-design was focused on reducing cost.

This first part of the away day was involved with the explanation of the principles behind the re-design the second part began the re-design of the process itself.

To build a new process and develop process maps the team performed a brainstorming exercise in which they generated 'post-its' of the activities that they undertook and the perceived needs of the customer. They then attempted to order these in terms of their affinity to each other. This caused some discussion but eventually the activities were grouped and possible cells established from the groupings. These cells were described temporarily as 'Design Things', Supply Parts for the Line' and 'Make Things'.

The outcome of each of the cells was also decided at that time. Each of these possible cells was to be responsible for the design of the cell and configuration of activities within it.

At the end of the away day is was decided that the next activities would involve:

- The identification of customer requirements
- The identification of interfaces between the cells
- Finalising the group/cell structure
- Identifying value added/non-value added activities

The next stages

Interfaces between cells

The members of each of the cells met and generated the sources, inputs, processes, outputs and receivers for their cells. This information along with that from the initial meeting was used to develop top-level process transformation diagrams for each of the cells. The interfaces between the cells were debated by all of the cells together until a consensus was reached that would enable smooth hand-overs between cells.

Customer requirements

Meetings were held with the Value Chains (customers), the Process Leader and representatives of the cell design team. At these meetings the perceived needs of the Value Chains and the inputs required to deliver those needs were reviewed and debated.

The questions included:

- Do you agree with the needs we perceive you want?
- What else do you need from us?
- What makes you happy with us?
- What makes you unhappy with us?

In some cases they found that they were producing outputs not required by the customer and in some cases were not delivering what the customer required. This informed decisions regarding value adding and non-value adding activities.

Bringing it all together

The top-level transformations that had been developed were reviewed and changed slightly on the basis of the customer requirements and identification of value and non-value adding activities. The final process maps were reviewed and agreement of them reached.

The remainder of the work involved the population of the cells with people and the development and appointment of people into the roles of cell leaders.

Results and the role of performance measures

The requirements for the Value Stream process were not expressed explicitly in the form of targets but rather as the reduction of cost and waste and the satisfaction of the customer.

The re-design once implemented led to the reduction in manufacturing lead-time from an average of 5 to 2 weeks. This was an excellent result and contributed to the general requirements expressed though it was not expressed explicitly at the start of the re-design. Performance Measures were developed for the cells some months later. In general they were successful at meeting these measures.

Interim results of the Process Re-engineering project

In December 1999 the success of the re-engineering project was reviewed. The results at that time, presented with regard to the customer, shareholders and people were found to be:

Customer

- Total customer focus
- Significant customer delight with 25% of the market wanting the company as a supplier or a partner
- A 58% increase in order intake
- Focussed business

Shareholder

- Same value adding throughput with 22% less people
- Only half way through improvements
- Forecast substantial improvements in Return on Sales and Capital Employed
- Self-sustained improvement

People

- Empowered multi-disciplined teams
- Process-based organisation
- People feel able to challenge
- Significant reduction in bureaucracy
- Improved people satisfaction

Appendix 2

Case B - The design and manufacture of security products

Case C - The manufacture of sealing systems for door assemblies

Case D - The fish smokers

Case B – The design and manufacture of security products

Overview

Company B is a privately owned company established in 1985. It is a small company that specialises in the design and manufacture of security products for the Cash-In-Transit (CIT) industry. Approximately 98% of all cash in the UK is carried in one of their security boxes.

The interview transcripts discuss process-based change in the company from 1995 through to 1997. During this period the company was continually growing and key changes included obtaining ISO 9000 accreditation, undertaking process improvements, beginning to use performance measures and an accreditation to Investors in People.

The information contained in the transcripts that deals specifically with business process re-design and performance measures was drawn out to form a view of these activities within the company.

Complex processes and ad-hoc process improvements

The processes used within the company before any change took place were *'convoluted and complex.'* When asked if they went through a process of analysis, understanding and simplification the company representative did not believe that they had not approached the change in such a scientific way but rather *'...judgementally when the need arose.'*

The vice president of manufacturing who had previously spent some years in a large company believed that *'If you were a bigger company and wanted to bring about change you'd think the thing through, identify the group of people that you want to take along with you, work at it as part of a team and implement it. When you're small, you haven't got a team. You've just got yourself and because of the way the company's grown you've got a whole bag full of issues that need to be sorted out and then you probably mentally prioritise these things and then start tackling them yourself.'*

Overall within Company B changes and process improvements were made on an ad-hoc basis when a problem arose or a need was identified.

The vice-president of manufacturing believed that *'...people in small companies didn't know what to do and they did need help and guidance.'*

CaseB1

Performance measures

In the initial stages of the process changes discussed Company B had no performance measures. They *'...weren't managing the company, we actually really didn't know where we were. We didn't know how much of the product had been delivered on time, we didn't know how much of that product was coming back - we knew a lot of it was, but we didn't know how much. So that was a fundamental issue.'*

They later employed a manufacturing expert who implemented operational performance measures regarding output, work in stores, field failures and response times and despatch reliability. These were the used to help identify the improvements required in production.

Case C – The manufacture of sealing systems for door assemblies

Overview

Company C is a small family business that manufactures sealing systems for door assemblies, which incorporate fire protection, smoke control, acoustic insulation and weather exclusion.

The interview transcripts discuss process-based change in the company from 1989 through to 1997. During this period the key changes included obtaining ISO 9000 accreditation, undertaking process improvements, beginning to use performance measures and the implementation of a factory management and total integrated manufacturing system.

The information contained in the transcripts that deals specifically with business process re-design and performance measures was drawn out to form a view of these activities within the company.

Performance measures and requirements

In 1995 the company brought in a production consultant to look at their processes. The outcome was *'an overstocking of product at that time we were improving our process and had mechanised lines. He was working on the principles that the lines should work 7 days a week, 24 hours a day, an efficiency sort of fella, all that happened was our stocks were going through the roof...'*

The company concentrated on efficiency and output alone, not on balanced Performance Requirements.

Measuring the process

Company C had extensive performance measures within manufacturing, which they used to provide feedback and give some indication of where improvements were required.

The owner of the company '... *decided to go in (to production) and basically start to get some measure on what we were doing. No one really knew how much we could make in a day, what we were capable of, shift guys, working overtime, not working overtime. What was our real delivery date and making sure sales quoted these delivery dates, not just the 4 days or 5 days, something they thought would sound nice to the customer....I just put in pretty rough measuring techniques really...*'

CaseC1

I started measuring what we were actually putting through to dispatch and the stock situation, then working out how many metres per minute or day we were capable of, which proved to be miles away from what our directors thought. They had done the calculations – our MD has an extrusion background he had done the calculations but we had horrendous scrap levels. Previously the supervisors and the new manager were just going on spec and weren't going on measurements and this fictitious scrap level of 3% in people's heads. But we were having a skip emptied 4 times a week, so I started going to the directors and saying our scrap is at 12%, that wasn't very good.'

Process re-design

Whilst the company had a fairly comprehensive set of performance measures within production that indicate where improvements might be required *'common sense'* was used *'...to put things right.'*

Case D - Fish smokers

Overview

Company D was established in 1993 from an insolvent unrelated company. It is a small privately owned business that processes and smokes fish. When interviewed the company was growing at 50% per year

The interview transcripts discuss process-based change in the company from 1993 through to 1997. During this period the company moved through three stages of growth, from an initial Mill Owner phase with tight controls, through an entrepreneurial phase when lots of process improvement took place to the new product development stage. The key episodes of change included the following of an ISO 9000 programme, investment in process and plant, Investors in People, the adoption of World Class Manufacturing techniques and the development of the strategic direction.

The information contained in the transcripts that deals specifically with business process re-design and performance measures was drawn out to form a view of these activities within the company.

Performance measures

Company D used a range of performance measurements to manage their business, they had '*...key Performance Indicators which measure the whole gambit of efficiency, yield, productivity, in terms of the conversion of raw material into finished product, customer complaints, quality control checks, rejects....*'

Strategy

It is evidential that company developed and made use of strategy to direct their organisation. According to the company representative interviewed it was *a 'strategic decision to go for volume and growth...'* and *' one of the other things that we went for concerning the business strategy also was trying to balance the business and the key things being quality of product...'*

The company's approach to re-design

Despite the strategy and performance measures process improvement and re-design was still approached in an unstructured manner with little understanding of the implications of the changes that they made. With regard to the process changes that they made they stated that *'It was fairly easy, you improve a bit then things get worse than they were before then they improve again. It happened 3 or 4 times across that time period (12 months) when you see things improve then you think sh*t and rethink, re-change, tinker whatever and start again, there were problems along the way...'* The company would '*....put things in place that were looked at for the first three to four months and then forgotten about, and were not monitored while we were off doing other things and then we came back maybe three months later and said oh look they're crap. We'd better do something about that.'*

Process re-engineering

The company focused on process re-engineering within production for '*....the maximisation of productivity and efficiency.*', aiming for 80% improvements in efficiency. World Class manufacturing was the means by which they undertook the efficiency improvements required in production.

Appendix 3

Preliminary questionnaire

Questionnaire - Links between Performance Criteria and Process Improvement Actions

Process Improvement Action / Performance Criteria	Reduce the number of activities within a process	Introduce a Case Manager, Worker or Team	Perform activities in parallel or concurrently	Eliminate non-value adding activities	Standardise	Simplify Language	Error Proof
Time							
Manufacturing Lead Time							
Cycle Time							
Lead Time Reliability							
Rework							
Set-up Time							
Inspection Time							
Distance Travelled							
Machine Down-time							
Output Rate							
Cost							
Labour Productivity							
Machine Productivity							
Rework							
Scrap							
Labour							
Inventory							
Material							
Inspection							
Work in Progress							
Total Operational Cost							
Labour Efficiency							
Machine Efficiency							
Quality							
Rework							
Scrap							
Yield							
Defects per Batch							
Rework Labour							
Inspection							
Non-conforming Product							
Flexibility							
Lead time to make Product							
Range of Products							
Predictable Output when Conditions Change							
Changeover Time							
Bottlenecks							

PrelimQ1

Questionnaire - Links between Performance Criteria and Process Improvement Actions

Performance Criteria \ Process Improvement Action	Move activities into the process	Move activities out of the process - to customer	Move activities out of the process - to supplier	Make the people or teams performing an activity responsible for it	Create alternative routes or paths through a process	Resequence activities	Use IT or technology to enable activities
Time							
Manufacturing Lead Time							
Cycle Time							
Lead Time Reliability							
Rework							
Set-up Time							
Inspection Time							
Distance Travelled							
Machine Down-time							
Output Rate							
Cost							
Labour Productivity							
Machine Productivity							
Rework							
Scrap							
Labour							
Inventory							
Material							
Inspection							
Work in Progress							
Total Operational Cost							
Labour Efficiency							
Machine Efficiency							
Quality							
Rework							
Scrap							
Yield							
Defects per Batch							
Rework Labour							
Inspection							
Non-Conforming Product							
Flexibility							
Lead time to make Product							
Range of Products							
Predictable Output when Conditions Change							
Changeover Time							
Bottlenecks							

PrelimQ2

Preliminary Questionnaire Definitions

Process Improvement Actions

1. Reduce the number of separate activities within a process.
Integrating separate activities or eliminating activities that already exist within the process can reduce the number of individual activities in a process. This will reduce the number of interfaces and hand-offs within a process.

2. Introduce a case manager, case workers or case team
A case manager acts as a single point of contact for the customer regarding the process and has access to all information regarding the process. Where the number of separate activities has been reduced by integration or elimination, an individual or a team can be used to perform the process and manage any remaining interfaces and hand-offs. This person or team can be referred to as a case-worker or case team.

3. Perform activities in parallel or concurrently
Activities within a process that are not dependent upon each other can be performed in parallel or concurrently. For example, the manufacture of two sub-components that are to be assembled into a final product need not be performed sequentially, but in parallel. Work may also be conducted concurrently by separate parts of a process and then integrated together as in the case of concurrent engineering.

4. Eliminate non-value adding activities.
Activities that are redundant, duplicated, outdated or driven by bureaucracy do not add value to a process. If these activities truly have no value within the process they should be eliminated.

5. Standardise
Process documentation, procedures and activities can be standardised so that everyone performs a process in the same way.

6. Simplify language
The verbal and written communication within a process can be simplified.

7. Error proof
Processes can be designed in such a way that it is impossible to make mistakes.

8. Move activities into the process
If activities are performed outside of the process on behalf of the process, such as information processing, purchasing, checking or a particular part of manufacturing they can be moved back into the appropriate place within the process.

9. Move activities out of the process
Activities that are performed by the process can be moved out of the process internally to another process or to someone external to the organisation. Activities can be moved to suppliers and customers.

10. Make the people or teams performing the activities responsible for the activity.
Where an activity, such as checking or inspection is moved back into the process then the work involved in completing that activity becomes the responsibility of the people within the process. This requires, particularly in the case of control and checking type activities that the people within the process take greater responsibility and make any decisions required. Increased responsibility can also be given to those performing the process through the use of self-managed teams.

11. Create multiple routes or paths through the process
Complex and simple work can be put through separate routes or separate process paths, perhaps after an initial triage.

12. Resequence activities
The sequence in which activities are performed can be changed. These activities may, or may not be geographically dispersed.

13. Use Information Technology (and technology) to enable activities and processes
Technology or information technology can be used to undertake an activity or process. For example, if a human performs an activity, the human can be replaced and the activity performed by a machine.
Information technology or technology can also be used merely to support another process improvement action.

Performance Criteria
Time
Manufacturing Lead Time
Start and finish time of the production process

Cycle Time
Time taken to manufacture a product including processing, moving, waiting, inspection and set-up time.

Lead Time Reliability
Consistency of lead times

Rework
Time spent on rework

Set-up Time
Time to set up for production

Inspection Time
Time spent on inspection activities

Distance Travelled
Distance work travels through the process

Machine Down-time
Time that machines are unavailable for production

Output Rate
The rate that products are generated by the process

Quality
Rework
Level of rework in process

Scrap
Level of scrap generated by process

Yield
Level of product that meets specification

Defects per Batch
Defective product per batch

Rework Labour
Rework labour compared to total direct labour for process

Inspection
Level of inspection activities

Non-conforming Product
Product that does not conform to specification

Cost
Labour Productivity
A comparison of finished products completed and the production hours taken to make them

Machine Productivity
A comparison of the number of hours a machine is running and the total number of working hours

Rework
Cost of rework

Scrap
Cost of scrap

Labour
Overall cost of labour

Inventory
Cost of inventory including raw material, work in progress and finished goods

Material
Cost of raw materials

Inspection
Cost of inspection activities

Work in Progress
Cost of work in progress

Total Operational Cost
Total cost to operate process

Labour Efficiency
A comparison of standard hours to actual hours

Machine Efficiency
A comparison of actual machine hours for a job and standard hours

Flexibility
Lead time to make Product
Start and finish time of product manufacture

Range of Products
The number of different products produced by the process

Predictable Output when Conditions Change
Consistency of output when conditions change such as absenteeism, breakdown etc.

Changeover Time
Time required to changeover to production of a different product

Bottlenecks
The number of bottleneck activities / workcentres

Appendix 4

Pilot questionnaire

Establishing the Links between Performance Requirements and the Changes that can be made to a Process

Time

To reduce Manufacturing Lead-time

	Strong Effect				No Effect
Reduce the number of activities within a process					
Performing activities in parallel rather than concurrently					
Eliminate non value-adding activities					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Resequence activities					

Other ....

To reduce Cycle-time

Reduce the number of activities within a process					
Performing activities in parallel rather than concurrently					
Eliminate non value-adding activities					
Resequence activities					

Other ....

To improve Lead-time Reliability

Introduce a Case Manager, Worker or Team					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					
Create alternative routes or paths through a process					
Use IT or technology to enable activities					

Other ....

To reduce Rework Time

Reduce the number of activities within a process					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce Set-up-time

Reduce the number of activities within a process.					
Eliminate non value-adding activities					
Standardise					
Make the people or teams performing an activity responsible for it.					
Using IT or Technology to enable activities.					

Other ....

To reduce Inspection Time

Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					
Use IT or technology to enable activities					

Other ....

To reduce the Distance Travelled

	Strong Effect				No Effect
Reduce the number of activities within a process.					
Performing activities in parallel rather than concurrently					
Eliminate non value-adding activities					
Move activities into the process					
Move activities out of the process – to the supplier					
Create alternative routes or paths through a process					
Resequence activities					

Other ....

To increase the Output Rate

Reduce the number of activities within a process					
Performing activities in parallel rather than concurrently					
Eliminate non value-adding activities					
Standardise					
Make the people or teams performing an activity responsible for it					

Other ....

Cost

To increase Labour Productivity

Reduce the number of activities within a process					
Eliminate non value-adding activities					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					

Other ....

To increase Machine Productivity

Reduce the number of activities within a process					
Performing activities in parallel rather than concurrently					
Eliminate non value-adding activities					
Error Proof					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					
Use IT or technology to enable activities					

Other ....

To reduce the Cost of Rework

Reduce the number of activities within a process					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					
Use IT or technology to enable activities					

Other ....

To reduce the Cost of Scrap

Introduce a Case Manager, Worker or Team					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce the Cost of Labour

	Strong Effect				No Effect
Reduce the number of activities within a process					
Performing activities in parallel rather than concurrently					
Eliminate non value-adding activities					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce the Cost of Inventory

Performing activities in parallel rather than concurrently					
Eliminate non value-adding activities					
Standardise					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					
Resequence activities					
Use IT or technology to enable activities					

Other ....

To reduce the Cost of Material

Eliminate non value-adding activities					
Standardise					
Error Proof					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					

Other ....

To reduce the Cost of Inspection

Eliminate non value-adding activities					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					
Use IT or technology to enable activities					

Other ....

To reduce the Cost of Work in Progress

Reduce the number of activities within a process					
Introduce a Case Manager, Worker or Team					
Performing activities in parallel rather than concurrently					
Eliminate non value-adding activities					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					

Other ....

To reduce the Total Operational Cost

Reduce the number of activities within a process					
Performing activities in parallel rather than concurrently					
Eliminate non value-adding activities					
Standardise					
Error Proof					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					

Other ....

PilotQ3

To increase Labour Efficiency	Strong Effect				No Effect
Reduce the number of activities within a process					
Introducing a Case Manager, Worker of Team					
Performing activities in parallel rather than concurrently					
Eliminate non value-adding activities					
Standardise					
Make the people or teams performing an activity responsible for it					

Other ....

To increase Machine Efficiency					
Reduce the number of activities within a process					
Performing activities in parallel rather than concurrently					
Eliminate non value-adding activities					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					
Create alternative routes or paths through a process					
Resequence activities					
Use IT or technology to enable activities					

Other ....

Quality

To reduce the Quantity of Rework					
Introduce a Case Manager, Worker or Team					
Standardise					
Error Proof					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce the Quantity of Scrap					
Reduce the number of activities within a process					
Standardise					
Error Proof					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					
Use IT or technology to enable activities					

Other ....

To increase Yield					
Introduce a Case Manager, Worker or Team					
Performing activities in parallel rather than concurrently					
Standardise					
Error Proof					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce the Defects per Batch

	Strong Effect				No Effect
Introduce a Case Manager, Worker or Team					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce the Rework Labour

Reduce the number of activities within a process					
Performing activities in parallel rather than concurrently					
Standardise					
Error Proof					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce the Number of Inspection Activities

Introduce a Case Manager, Worker or Team					
Standardise					
Error Proof					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce Non-conforming Product

Reduce the number of activities within a process					
Introduce a Case Manager, Worker or Team					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					

Other ....

Flexibility

To reduce the Lead-time to Make a Product

Reduce the number of activities within a process					
Performing activities in parallel rather than concurrently					
Eliminate non value-adding activities					
Standardise					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Create alternative routes or paths through a process					

Other ....

To increase the Range of Products

Reduce the number of activities within a process					
Performing activities in parallel rather than concurrently					
Standardise					
Move activities into the process					
Create alternative routes or paths through a process					
Use IT or technology to enable activities					

Other ....

To achieve a Predictable Output when Conditions Change

	Strong Effect				No Effect
Introduce a Case Manager, Worker or Team					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					
Create alternative routes or paths through a process					
Use IT or technology to enable activities					

Other ....

To reduce Changeover Time

Reduce the number of activities within a process.					
Introduce a Case Manager, Worker or Team					
Performing activities in parallel rather than concurrently					
Eliminate non value-adding activities					
Standardise					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce Bottlenecks

Reduce the number of activities within a process					
Performing activities in parallel rather than concurrently					
Eliminate non value-adding activities					
Move activities out of the process – to the supplier					
Create alternative routes or paths through a process					
Resequence activities					

Other ....

Details of Respondent

Please complete the following:

Current Position in Company

Key responsibilities of Position

(particularly in relation to process redesign and improvement)

Pilot questionnaire definitions

Process Improvement Actions

1. Reduce the number of separate activities within a process.
Integrating separate activities or eliminating duplicate activities within a process can reduce the number of individual activities in the process. This will reduce the number of interfaces and hand-offs within the process.

2. Introduce a case manager, caseworkers or case team
A case manager acts as a single point of contact for the customer regarding a process and has access to all information regarding the process. Where the number of separate activities has been reduced by integration or elimination, an individual or a team can be used to perform the process and manage any remaining interfaces and hand-offs. This person or team can be referred to as a caseworker or case team.

3. Perform activities in parallel or concurrently
Activities within a process that are not dependent upon each other can be performed in parallel or concurrently. For example, the manufacture of two sub-components that are to be assembled into a final product need not be performed sequentially, but in parallel. Work may also be conducted concurrently by separate parts of a process and then integrated together as in the case of concurrent engineering.

4. Eliminate non-value adding activities.
Activities that are redundant, duplicated, outdated or driven by bureaucracy do not add value to a process. If these activities truly have no value within the process they should be eliminated.

5. Standardise
Process documentation, procedures and activities can be standardised so that everyone performs the process in the same way.

6. Simplify language
The verbal and written communication within a process can be simplified so it is easily understood.

7. Error proof
Processes can be designed so that there is only one way to perform them; therefore it is impossible to make mistakes.

8. Move activities into the process
If activities are performed outside of a process on behalf of the process, such as information processing, purchasing, or manufacture of a particular part they can be moved back into the appropriate place within the process.

9. Move activities out of the process
Activities that are performed by a process can be moved out of the process internally to another process or to someone external to the organisation. They can be moved to internal or external suppliers or internal or external customers' dependant on the activity and its position within the process.

10. Make the people or teams performing the activities responsible for the activity.
Where an activity, such as purchasing or inspection is moved back into a process then the work involved in completing that activity becomes the responsibility of the people within the process. This requires, particularly in the case of control and checking type activities that the people within the process take greater responsibility and make any decisions required. Increased responsibility can also be given to those performing the process through the use of self-managed teams.

11. Create multiple routes or paths through the process
It can be determined whether work is complex or simple, possibly by a triage stage and can be progressed through the appropriate, separate routes or paths of a process.

12. Resequence activities
The sequence in which activities are performed can be changed. These activities may, or may not be geographically dispersed.

13. Use Information Technology (and technology) to enable activities and processes
Technology or information technology can be used to undertake an activity or process. For example, if a human performs an activity, the human can be replaced and the activity performed by a machine.
Information technology or technology can also be used merely to support another process improvement action or the performance of an activity.

Performance Criteria

Time

Manufacturing Lead-Time - The total time taken between receipt of an order by manufacturing and them satisfying that order.

Cycle Time - The time taken to complete one cycle of a process including processing, moving, waiting, inspection and set-up time.

Lead Time Reliability - The extent to which the lead times taken to undertake the work is consistent and so predictable.

Rework Time - The time spent rectifying work that was produced incorrectly or was defective the first time.

Set-up Time - The time that it takes to perform the activities required to set-up machines or prepare to undertake work within a process.

Inspection Time - The total time that it takes to perform the inspection, checking and monitoring activities within a process.

Distance Traveled - The distance that work travels whilst been progressed from the start to the finish of the process.

Output Rate - The rate at which completed work emerges from the process e.g. 100 parts per hour.

Quality

Rework Quantity - The amount of the work produced that does not meet specification or is defective and must be reworked to rectify it.

Scrap Quantity - The amount of scrap resulting from the process, particularly work completed incorrectly or not meeting specification that must be thrown away.

Yield - The amount of the work produced that when subject to test (against specification) passes.

Defects per Batch - The number or percentage in a batch that do not meet specification or are defective.

Rework Labour - The extra labour required rectifying work that was produced incorrectly or was defective the first time.

Number of Inspection Activities - The number of activities within the process that are concerned with the inspection checking or monitoring of work.

Non-conforming Product - The percentage of the work produced that does not conform to the original specification set for it.

Cost

Labour Productivity - A comparison of the quantity of work completed and the actual time taken to complete it.

Machine Productivity - A comparison of the quantity of work produced by a machine against the total number of hours the machine was running to produce it.

Cost of Rework - The cost of rectifying the work produced that does not meet specification or is defective.

Cost of Scrap - The cost of the scrap resulting from the process, particularly work completed incorrectly or not meeting specification that must be thrown away.

Cost of Labour - The overall cost of the labour required operating the process and generating the required output.

Cost of Inventory - The cost of the inventory within a process including raw material, work in progress and finished goods

Cost of Material - The cost of the raw material consumed by the process in order to generate the required output.

Cost of Inspection - The cost of the activities within the process concerned with the inspection, monitoring and checking of work.

Cost of Work in Progress - The cost of the work that is been worked on by the process (in progress).

Total Operational Cost - The total cost incurred in operating the process.

Labour Efficiency - A comparison of the actual hours taken to produce work against the standard hours budgeted to produce it.

Machine Efficiency - A comparison of actual machine hours taken to produce work against the standard machine hours budgeted to produce it.

Flexibility

Lead time to make Product - The total time taken between receipt of an order by manufacturing and them satisfying that order.

Range of Products - The number of different products or outputs the process is capable of generating

Predictable Output when Conditions Change
Consistency of output when conditions change such as absenteeism, breakdown etc.

Changeover Time
The time required changing the process over from production of one product or output to a different product or outcome.

Bottlenecks
The number of activities within a process at which queues occur and work is held up.

Appendix 5

Final questionnaire

Establishing the Links between Performance Requirements and the Changes that can be made to a Process

Instructions for Completion

The questionnaire is presented in four sections, time, cost, quality and flexibility. Within each of these sections there is a list of relevant Performance Requirements. Each Performance Requirement is accompanied by a set of statements that express a positive link between the Performance Requirement and a Process Improvement Action.

In order to complete the questionnaire could you please indicate on the scale the effect that you consider the Process Improvement Action will have on improving the Performance Requirement. The scale is labelled from 1 - No Effect to 5 - Strong Effect. If you believe that there is a Process Improvement Action that would have a positive effect on the stated Performance Requirement but is not included in the links offered, please state it under 'other'.

Definitions of the Performance Requirements and Process Improvement Actions are included as separate sheets to clarify the terms used.

The questionnaire applies specifically to the process of making a product and therefore does not include purchasing or scheduling; neither does it encompass the technical details of the tasks or individual machines encompassed in the process.

The Questionnaire

Time

To reduce Manufacturing Lead-time	5 (Strong Effect)	4	3	2	1 (No Effect)
Reduce the number of activities within a process					
Perform activities in parallel rather than sequentially					
Eliminate non value-adding activities					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Resequence activities					

Other ....

To reduce Cycle-time	5	4	3	2	1
Reduce the number of activities within a process					
Perform activities in parallel rather than sequentially					
Eliminate non value-adding activities					
Move activities into the process					
Resequence activities					

Other ....

To improve Lead-time Reliability	5	4	3	2	1
Introduce a Case Manager, Worker or Team					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					
Create alternative routes or paths through a process					
Use IT or technology to enable activities					

Other ....

To reduce Rework Time	5	4	3	2	1
Reduce the number of activities within a process					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce Set-up-time	5	4	3	2	1
Reduce the number of activities within a process.					
Introduce a Case Manager, Worker or Team					
Eliminate non value-adding activities					
Standardise					
Make the people or teams performing an activity responsible for it.					
Using IT or Technology to enable activities					

Other ....

To reduce Inspection Time	5 Strong Effect	4	3	2	1 No Effect
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					
Use IT or technology to enable activities					

Other ....

To reduce the Distance Travelled	5	4	3	2	1
Reduce the number of activities within a process.					
Perform activities in parallel rather than sequentially					
Eliminate non value-adding activities					
Error Proofing					
Move activities into the process					
Move activities out of the process – to the supplier					
Create alternative routes or paths through a process					
Resequence activities					

Other ....

To increase the Output Rate	5	4	3	2	1
Reduce the number of activities within a process					
Perform activities in parallel rather than sequentially					
Eliminate non value-adding activities					
Standardise					
Make the people or teams performing an activity responsible for it					

Other ....

Cost

To reduce the Cost of Rework	5	4	3	2	1
Reduce the number of activities within a process					
Perform activities in parallel rather than sequentially					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					
Use IT or technology to enable activities					

Other ....

To increase Machine Productivity	5	4	3	2	1
Reduce the number of activities within a process					
Perform activities in parallel rather than sequentially					
Eliminate non value-adding activities					
Error Proof					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					
Use IT or technology to enable activities					

Other ....

To increase Labour Productivity

	Strong Effect 5	4	3	2	No Effect 1
Reduce the number of activities within a process					
Eliminate non value-adding activities					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce the Cost of Inspection

	5	4	3	2	1
Eliminate non value-adding activities					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					
Use IT or technology to enable activities					

Other ....

To reduce the Cost of Labour

	5	4	3	2	1
Reduce the number of activities within a process					
Perform activities in parallel rather than sequentially					
Eliminate non value-adding activities					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce the Cost of Inventory

	5	4	3	2	1
Perform activities in parallel rather than sequentially					
Eliminate non value-adding activities					
Standardise					
Move activities into the process					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					
Resequence activities					
Use IT or technology to enable activities					

Other ....

To reduce the Cost of Material

	5	4	3	2	1
Eliminate non value-adding activities					
Standardise					
Error Proof					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					

Other ....

To reduce the Cost of Scrap	5 Strong Effect	4	3	2	1 No Effect
Introduce a Case Manager, Worker or Team					
Perform activities in parallel rather than sequentially					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce the Cost of Work in Progress	5	4	3	2	1
Reduce the number of activities within a process					
Introduce a Case Manager, Worker or Team					
Perform activities in parallel rather than sequentially					
Eliminate non value-adding activities					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					

Other ....

To reduce the Total Operational Cost	5	4	3	2	1
Reduce the number of activities within a process					
Perform activities in parallel rather than sequentially					
Eliminate non value-adding activities					
Standardise					
Error Proof					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					

Other ....

To increase Labour Efficiency	5	4	3	2	1
Reduce the number of activities within a process					
Introduce a Case Manager, Worker or Team					
Perform activities in parallel rather than sequentially					
Eliminate non value-adding activities					
Standardise					
Make the people or teams performing an activity responsible for it					

Other ....

To increase Machine Efficiency	5	4	3	2	1
Reduce the number of activities within a process					
Perform activities in parallel rather than sequentially					
Eliminate non value-adding activities					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					
Create alternative routes or paths through a process					
Resequence activities					
Use IT or technology to enable activities					

Other ....

Quality

To reduce the Quantity of Rework

	5 (Strong Effect)	4	3	2	1 (No Effect)
Introduce a Case Manager, Worker or Team					
Standardise					
Error Proof					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					
Create alternative routes or paths through a process					

Other ....

To reduce the Quantity of Scrap

	5	4	3	2	1
Reduce the number of activities within a process					
Standardise					
Error Proof					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					
Use IT or technology to enable activities					

Other ....

To increase Yield

	5	4	3	2	1
Reduce the number of activities within a process					
Introduce a Case Manager, Worker or Team					
Perform activities in parallel rather than sequentially					
Standardise					
Error Proof					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce the Defects per Batch

	5	4	3	2	1
Introduce a Case Manager, Worker or Team					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					
Resequence Activities					

Other ....

To reduce the Rework Labour

	5	4	3	2	1
Reduce the number of activities within a process					
Perform activities in parallel rather than sequentially					
Standardise					
Error Proof					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce the Number of Inspection Activities

	5 Strong Effect	4	3	2	1 No Effect
Introduce a Case Manager, Worker or Team					
Standardise					
Error Proof					
Move activities out of the process – to the supplier					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce Non-conforming Product

	5	4	3	2	1
Reduce the number of activities within a process					
Perform activities in parallel rather than sequentially					
Introduce a Case Manager, Worker or Team					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					

Other ....

Flexibility

To reduce the Lead-time to Make a Product

	5	4	3	2	1
Reduce the number of activities within a process					
Perform activities in parallel rather than sequentially					
Eliminate non value-adding activities					
Standardise					
Move activities out of the process – to the customer					
Move activities out of the process – to the supplier					
Create alternative routes or paths through a process					

Other ....

To increase the Range of Products

	5	4	3	2	1
Reduce the number of activities within a process					
Perform activities in parallel rather than sequentially					
Standardise					
Move activities into the process					
Create alternative routes or paths through a process					
Use IT or technology to enable activities					

Other ....

To achieve a Predictable Output when Conditions Change

		4	3	2	1
Introduce a Case Manager, Worker or Team					
Standardise					
Error Proof					
Make the people or teams performing an activity responsible for it					
Move activities out of the process – to the customer					
Create alternative routes or paths through a process					
Use IT or technology to enable activities					

Other ....

To reduce Changeover Time	5 Strong Effect	4	3	2	1 No Effect
Reduce the number of activities within a process.					
Introduce a Case Manager, Worker or Team					
Perform activities in parallel rather than sequentially					
Eliminate non value-adding activities					
Standardise					
Make the people or teams performing an activity responsible for it					

Other ....

To reduce Bottlenecks	5	4	3	2	1
Reduce the number of activities within a process					
Perform activities in parallel rather than sequentially					
Eliminate non value-adding activities					
Move activities out of the process – to the supplier					
Create alternative routes or paths through a process					
Resequence activities					

Other ....

Details of Respondent

Name

Email

Current Job Role

About your Process Redesign Experience

Years of experience

Industries experience is from

Size of companies worked in

Is your background in

Engineering ☐ Finance ☐
Commercial ☐ Quality ☐
Gen.Mgmt. ☐ IT ☐

Other ....

FinalQ8

Final questionnaire definitions

Process Improvement Actions

1. Reduce the number of separate activities within a process.
Integrating separate activities or eliminating duplicate activities within a process can reduce the number of individual activities in the process. This will reduce the number of interfaces and hand-offs within the process.

2. Introduce a case manager, caseworkers or case team
A case manager acts as a single point of contact for the customer regarding a process and has access to all information regarding the process. Where the number of separate activities has been reduced by integration or elimination, an individual or a team can be used to perform the process and manage any remaining interfaces and hand-offs. This person or team can be referred to as a caseworker or case team.

3. Perform activities in parallel or concurrently
Activities within a process that are not dependent upon each other can be performed in parallel or concurrently. For example, the manufacture of two sub-components that are to be assembled into a final product need not be performed sequentially, but in parallel. Work may also be conducted concurrently by separate parts of a process and then integrated together as in the case of concurrent engineering.

4. Eliminate non-value adding activities.
Activities that are redundant, duplicated, outdated or driven by bureaucracy do not add value to a process. If these activities truly have no value within the process they should be eliminated.

5. Standardise
Process documentation, procedures and activities can be standardised so that everyone performs the process in the same way.

6. Simplify language
The verbal and written communication within a process can be simplified so it is easily understood.

7. Error proof
Processes can be designed so that there is only one way to perform them; therefore it is impossible to make mistakes.

8. Move activities into the process
If activities are performed outside of a process on behalf of the process, such as information processing, purchasing, or manufacture of a particular part they can be moved back into the appropriate place within the process.

9. Move activities out of the process
Activities that are performed by a process can be moved out of the process internally to another process or to someone external to the organisation. They can be moved to internal or external suppliers or internal or external customers' dependant on the activity and its position within the process.

10. Make the people or teams performing the activities responsible for the activity.
Where an activity, such as purchasing or inspection is moved back into a process then the work involved in completing that activity becomes the responsibility of the people within the process. This requires, particularly in the case of control and checking type activities that the people within the process take greater responsibility and make any decisions required. Increased responsibility can also be given to those performing the process through the use of self-managed teams.

11. Create multiple routes or paths through the process
It can be determined whether work is complex or simple, possibly by a triage stage and can be progressed through the appropriate, separate routes or paths of a process.

12. Resequence activities
The sequence in which activities are performed can be changed. These activities may, or may not be geographically dispersed.

13. Use Information Technology (and technology) to enable activities and processes
Technology or information technology can be used to undertake an activity or process. For example, if a human performs an activity, the human can be replaced and the activity performed by a machine.
Information technology or technology can also be used merely to support another process improvement action or the performance of an activity.

Performance Criteria

Time

Manufacturing Lead-Time - The total time taken between receipt of an order by manufacturing and them satisfying that order.

Cycle Time - The time taken to complete one cycle of a process including processing, moving, waiting, inspection and set-up time.

Lead Time Reliability - The extent to which the lead times taken to undertake the work is consistent and so predictable.

Rework Time - The time spent rectifying work that was produced incorrectly or was defective the first time.

Set-up Time - The time that it takes to perform the activities required to set-up machines or prepare to undertake work within a process.

Inspection Time - The total time that it takes to perform the inspection, checking and monitoring activities within a process.

Distance Traveled - The distance that work travels whilst been progressed from the start to the finish of the process.

Output Rate - The rate at which completed work emerges from the process e.g. 100 parts per hour.

Quality

Rework Quantity - The amount of the work produced that does not meet specification or is defective and must be reworked to rectify it.

Scrap Quantity - The amount of scrap resulting from the process, particularly work completed incorrectly or not meeting specification that must be thrown away.

Yield - The amount of the work produced that when subject to test (against specification) passes.

Defects per Batch - The number or percentage in a batch that do not meet specification or are defective.

Rework Labour - The extra labour required rectifying work that was produced incorrectly or was defective the first time.

Number of Inspection Activities - The number of activities within the process that are concerned with the inspection checking or monitoring of work.

Non-conforming Product - The percentage of the work produced that does not conform to the original specification set for it.

Cost

Labour Productivity - A comparison of the quantity of work completed and the actual time taken to complete it.

Machine Productivity - A comparison of the quantity of work produced by a machine against the total number of hours the machine was running to produce it.

Cost of Rework - The cost of rectifying the work produced that does not meet specification or is defective.

Cost of Scrap - The cost of the scrap resulting from the process, particularly work completed incorrectly or not meeting specification that must be thrown away.

Cost of Labour - The overall cost of the labour required operating the process and generating the required output.

Cost of Inventory - The cost of the inventory within a process including raw material, work in progress and finished goods

Cost of Material - The cost of the raw material consumed by the process in order to generate the required output.

Cost of Inspection - The cost of the activities within the process concerned with the inspection, monitoring and checking of work.

Cost of Work in Progress - The cost of the work that is been worked on by the process (in progress).

Total Operational Cost - The total cost incurred in operating the process.

Labour Efficiency - A comparison of the actual hours taken to produce work against the standard hours budgeted to produce it.

Machine Efficiency - A comparison of actual machine hours taken to produce work against the standard machine hours budgeted to produce it.

Flexibility

Lead time to make Product - The total time taken between receipt of an order by manufacturing and them satisfying that order.

Range of Products - The number of different products or outputs the process is capable of generating

Predictable Output when Conditions Change
Consistency of output when conditions change such as absenteeism, breakdown etc.

Changeover Time
The time required changing the process over from production of one product or output to a different product or outcome.

Bottlenecks
The number of activities within a process at which queues occur and work is held up.

Appendix 6

Descriptive statistics

Descriptive Statistics - Time

To reduce manufacturing lead-time

		T1A	T1B	T1C	T1D	T1E	T1F
N	Valid	28	29	29	29	28	29
	Missing	1	0	0	0	1	0
Median		4.00	4.00	5.00	3.00	3.00	3.00
Mode		5	5	5	2[a]	3	2[a]

a. Multiple modes exist. The smallest value is shown

To reduce cycle time

		T2A	T2B	T2C	T2G	T2F
N	Valid	29	29	29	29	29
	Missing	0	0	0	0	0
Median		5.00	4.00	5.00	3.00	3.00
Mode		5	5	5	3	3

To improve lead-time reliability

		T3H	T3I	T3J	T3K	T3L	T3M
N	Valid	29	29	29	29	29	29
	Missing	0	0	0	0	0	0
Median		3.00	4.00	4.00	5.00	3.00	4.00
Mode		3	4	5	5	2[a]	4

a. Multiple modes exist. The smallest value is shown

To reduce rework time

Statistics		T4A	T4I	T4J	T4K
N	Valid	29	29	28	29
	Missing	0	0	1	0
Median		4.00	5.00	5.00	5.00
Mode		5	5	5	5

To reduce set-up time

		T5A	T5H	T5C	T5I	T5K	T5M
N	Valid	29	29	29	29	29	29
	Missing	0	0	0	0	0	0
Median		4.00	3.00	5.00	5.00	4.00	3.00
Mode		4	4	5	5	5	3

To reduce inspection time

		T6I	T6J	T6K	T6M
N	Valid	28	28	29	29
	Missing	1	1	0	0
Median		5.00	5.00	4.00	3.00
Mode		5	5	5	2

DescriptiveTime2

To reduce distance travelled

		T7A	T7B	T7C	T7J	T7G	T7E	T7L	T7F
N	Valid	29	28	29	29	28	28	29	29
	Missing	0	1	0	0	1	1	0	0
Median		4.00	3.00	5.00	3.00	3.00	3.00	3.00	4.00
Mode		5	2	5	3	1	3[a]	2	4

a. Multiple modes exist. The smallest value is shown

To increase output rate

		T8A	T8B	T8C	T8I	T8K
N	Valid	29	29	29	29	29
	Missing	0	0	0	0	0
Median		5.00	4.00	5.00	5.00	4.00
Mode		5	4[a]	5	5	5

a. Multiple modes exist. The smallest value is shown

Descriptive statistics - Cost

To reduce cost of rework

		C1A	C1B	C1I	C1J	C1K	C1M
N	Valid	29	29	29	29	29	28
	Missing	0	0	0	0	0	1
Median		4.00	2.00	4.00	5.00	5.00	3.00
Mode		4	1	5	5	5	2[a]

a. Multiple modes exist. The smallest value is shown

To increase machine productivity

		C2A	C2B	C2C	C2J	C2D	C2E	C2K	C2M
N	Valid	29	29	29	29	29	29	29	29
	Missing	0	0	0	0	0	0	0	0
Median		4.00	3.00	5.00	4.00	2.00	3.00	4.00	3.00
Mode		5	5	5	5	1[a]	4	5	5

a. Multiple modes exist. The smallest value is shown

To increase labour productivity

		C3A	C3C	C3I	C3J	C3K
N	Valid	29	29	29	29	29
	Missing	0	0	0	0	0
Median		4.00	5.00	4.00	4.00	5.00
Mode		5	5	5	4[a]	5

a. Multiple modes exist. The smallest value is shown

To reduce cost of inspection

		C4C	C4I	C4J	C4K	C4M
N	Valid	29	29	29	29	27
	Missing	0	0	0	0	2
Median		4.00	5.00	5.00	4.00	3.00
Mode		5	5	5	5	3

To reduce cost of labour

		C5A	C5B	C5C	C5D	C5E	C5K
N	Valid	29	29	29	28	28	29
	Missing	0	0	0	1	1	0
Median		4.00	3.00	5.00	3.00	4.00	4.00
Mode		5	1	5	5	5	5

To reduce cost of inventory

		C6B	C6C	C6I	C6G	C6D	C6E	C6K	C6F	C6M
N	Valid	29	29	29	27	28	28	29	28	29
	Missing	0	0	0	2	1	1	0	1	0
Median		2.00	3.00	5.00	2.00	3.00	4.00	4.00	2.00	4.00
Mode		1	5	5	1	1	5	5	1	5

To reduce cost of material

		C7C	C7I	C7J	C7D	C7E
N	Valid	29	29	29	29	28
	Missing	0	0	0	0	1
Median		3.00	5.00	4.00	2.00	3.50
Mode		5	5	5	1	5

To reduce cost of scrap

Statistics		C8H	C8B	C8I	C8J	C8K
N	Valid	29	29	29	29	29
	Missing	0	0	0	0	0
Median		4.00	1.00	4.00	5.00	5.00
Mode		4	1	5	5	5

To reduce cost of work in progress

		C9A	C9H	C9B	C9C	C9D	C9E
N	Valid	29	28	29	29	29	29
	Missing	0	1	0	0	0	0
Median		4.00	3.00	4.00	4.00	3.00	4.00
Mode		5	4	5	5	5	5

To reduce total operational cost

		C10A	C10B	C10C	C10I	C10J	C10D	C10E
N	Valid	29	29	29	29	29	29	29
	Missing	0	0	0	0	0	0	0
Median		5.00	3.00	5.00	5.00	5.00	3.00	4.00
Mode		5	1[a]	5	5	5	2	4

a. Multiple modes exist. The smallest value is shown

To increase labour efficiency

		C11A	C11H	C11B	C11C	C11I	C11K
N	Valid	29	28	29	29	29	29
	Missing	0	1	0	0	0	0
Median		4.00	4.00	3.00	5.00	5.00	5.00
Mode		5	4	3[a]	5	5	5

a. Multiple modes exist. The smallest value is shown

To increase machine efficiency

		C12A	C12B	C12C	C12I	C12J	C12K	C12L	C12F	C12M
N	Valid	29	29	29	29	29	29	29	29	29
	Missing	0	0	0	0	0	0	0	0	0
Median		4.00	3.00	5.00	5.00	5.00	4.00	3.00	3.00	4.00
Mode		5	1[a]	5	5	5	5	3	3	4

a. Multiple modes exist. The smallest value is shown

Descriptive statistics - Quality

To reduce quantity of rework

		Q1H	Q1I	Q1J	Q1D	Q1E	Q1K	Q1L
N	Valid	28	29	29	28	28	27	29
	Missing	1	0	0	1	1	2	0
Median		4.00	5.00	5.00	2.00	3.00	5.00	2.00
Mode		4	5	5	1	3[a]	5	3

a. Multiple modes exist. The smallest value is shown

To reduce quantity of scrap

		Q2A	Q2I	Q2J	Q2E	Q2K	Q2M
N	Valid	28	28	27	26	27	28
	Missing	1	1	2	3	2	1
Median		3.00	5.00	5.00	3.00	4.00	3.00
Mode		3	5	5	3	4[a]	3

a. Multiple modes exist. The smallest value is shown

To increase yield

		Q3A	Q3H	Q3B	Q3I	Q3J	Q3D	Q3E	Q3K
N	Valid	28	29	28	29	29	28	28	28
	Missing	1	0	1	0	0	1	1	1
Median		4.00	4.00	3.00	5.00	5.00	2.00	3.00	4.00
Mode		5	4	1[a]	5	5	1	1[a]	5

a. Multiple modes exist. The smallest value is shown

DescriptiveQuality1

To reduce defects per batch

		Q4H	Q4I	Q4J	Q4K	Q4F
N	Valid	28	28	29	29	28
	Missing	1	1	0	0	1
Median		4.00	5.00	5.00	4.00	2.00
Mode		4	5	5	5	2

To reduce rework labour

		Q5A	Q5B	Q5I	Q5J	Q5D	Q5E	Q5K
N	Valid	29	28	29	29	28	27	29
	Missing	0	1	0	0	1	2	0
Median		4.00	2.00	5.00	5.00	2.00	3.00	4.00
Mode		5	1	5	5	1	3	4[a]

a. Multiple modes exist. The smallest value is shown

To reduce the number of inspection activities

		Q6H	Q6I	Q6J	Q6E	Q6K
N	Valid	28	28	29	28	28
	Missing	1	1	0	1	1
Median		3.00	5.00	5.00	3.00	4.00
Mode		3	5	5	3[a]	5

a. Multiple modes exist. The smallest value is shown

To reduce non-conforming product

		Q7A	Q7B	Q7H	Q7I	Q7J	Q7K
N	Valid	28	28	29	29	29	29
	Missing	1	1	0	0	0	0
Median		3.00	2.00	4.00	5.00	5.00	5.00
Mode		3	1[a]	4	5	5	5

a. Multiple modes exist. The smallest value is shown

Descriptive statistics - Flexibility

To reduce the lead-time to make product

		F1A	F1B	F1C	F1I	F1D	F1E	F1L
N	Valid	28	28	28	28	27	27	28
	Missing	1	1	1	1	2	2	1
Median		5.00	4.50	5.00	5.00	3.00	3.00	3.00
Mode		5	5	5	5	1	3	3

To increase the range of products

		F2A	F2B	F2I	F2G	F2L	F2M
N	Valid	28	28	28	28	27	29
	Missing	1	1	1	1	2	0
Median		3.00	3.00	3.00	3.00	3.00	4.00
Mode		3	1[a]	5	3	3	3
Range		4	4	4	4	4	4
Percentiles	25	2.00	1.00	2.00	1.25	2.00	3.00
	50	3.00	3.00	3.00	3.00	3.00	4.00
	75	4.00	4.00	5.00	3.75	4.00	5.00

a. Multiple modes exist. The smallest value is shown

To achieve predicatable output when conditions change

		F3H	F3I	F3J	F3K	F3D	F3L	F3M
N	Valid	28	29	29	29	26	28	29
	Missing	1	0	0	0	3	1	0
Median		4.00	4.00	5.00	4.00	2.00	3.00	3.00
Mode		4[a]	5	5	5	2	3	5

a. Multiple modes exist. The smallest value is shown

To reduce changeover time

		F4A	F4H	F4B	F4C	F4I	F4K
N	Valid	28	28	28	28	28	28
	Missing	1	1	1	1	1	1
Median		5.00	3.00	4.00	5.00	5.00	4.00
Mode		5	3	5	5	5	5

To reduce bottlenecks

		F5A	F5B	F5C	F5E	F5L	F5F
N	Valid	29	28	29	29	29	29
	Missing	0	1	0	0	0	0
Mean		3.62	3.54	4.34	3.69	3.76	3.72
Mode		4	5	5	5	4[a]	4

a. Multiple modes exist. The smallest value is shown

DescriptiveFlexibility2

Appendix 7

Inferential statistics - The Wilcoxon Matched Pairs Test results

Wilcoxon Test Results - Time

To reduce manufacturing lead-time[c]

	T1B - T1A	T1C - T1A	T1C - T1B
Z	-.692[a]	-1.655[b]	-2.194[b]
Asymp. Sig. (2-tailed)	.489	.098	.028

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

To reduce cycle time[c]

	T2B - T2A	T2C - T2A	T2C - T2B
Z	-1.945[a]	-.728[b]	-3.082[b]
Asymp. Sig. (2-tailed)	.052	.467	.002

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

To improve lead-time reliability[c]

Statistics	T3J - T3I	T3K - T3I	T3M - T3I	T3K - T3J	T3M - T3J	T3M - T3K
Z	-.353[b]	-.623[a]	-1.939[b]	-1.224[a]	-1.545[b]	-2.146[b]
Asymp. Sig. (2-tailed)	.724	.533	.052	.221	.122	.032

a. Based on negative ranks.

b. Based on positive ranks.

c. Wilcoxon Signed Ranks Test

WilcoxonTime1

To reduce rework time[c]

	T4I - T4A	T4J - T4A	T4K - T4A	T4J - T4I	T4K - T4I	T4K - T4J
Z	-3.104[a]	-3.416[a]	-2.744[a]	-.954[a]	-.413[b]	-1.268[b]
Asymp. Sig. (2-tailed)	.002	.001	.006	.340	.680	.205

a. Based on negative ranks.

b. Based on positive ranks.

c. Wilcoxon Signed Ranks Test

To reduce set-up time[c]

	T5C - T5A	T5I - T5A	T5K - T5A	T5I - T5C	T5K - T5C	T5K - T5I
Z	-1.488[b]	-2.091[b]	-.505[a]	-.844[b]	-2.044[a]	-2.452[a]
Asymp. Sig. (2-tailed)	.137	.037	.614	.399	.041	.014

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

To reduce inspection time[c]

	T6J - T6I	T6K - T6I	T6K - T6J
Z	-.929[a]	-.864[b]	-1.807[b]
Asymp. Sig. (2-tailed)	.353	.388	.071

a. Based on negative ranks.

b. Based on positive ranks.

c. Wilcoxon Signed Ranks Test

WilcoxonTime2

To reduce distance travelled[d]

	T7C - T7A	T7F - T7A	T7F - T7C
Z	-1.283[b]	-2.251[a]	-2.680[a]
Asymp. Sig. (2-tailed)	.200	.024	.007

a. Based on positive ranks.

b. Based on negative ranks.

d. Wilcoxon Signed Ranks Test

To increase output rate[c]

	T8B - T8A	T8C - T8A	T8I - T8A	T8K - T8A	T8C - T8B	T8I - T8B	T8K - T8B	T8I - T8C	T8K - T8C	T8K - T8I
Z	-2.357[a]	-.457[b]	-.558[b]	-.949[a]	-2.567[b]	-2.348[b]	-1.063[b]	-.321[b]	-1.333[a]	-1.629[a]
Asymp. Sig. (2-tailed)	.018	.647	.577	.342	.010	.019	.288	.748	.183	.103

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

Wilcoxon Test Results - Cost

Reduce cost of rework[c]

	C1I - C1A	C1J - C1A	C1K - C1A	C1J - C1I	C1K - C1I	C1K - C1J
Z	-2.522[b]	-2.829[b]	-2.523[b]	-1.714[b]	-.121[b]	-.992[a]
Asymp. Sig. (2-tailed)	.012	.005	.012	.087	.904	.321

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

Increase machine efficiency[c]

	C2C - C2A	C2J - C2A	C2K - C2A	C2J - C2C	C2K - C2C	C2K - C2J
Z	-2.247[b]	-1.085[b]	-.388[b]	-1.467[a]	-1.876[a]	-.942[a]
Asymp. Sig. (2-tailed)	.025	.278	.698	.142	.061	.346

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

Increase labour productivity[c]

	C3C - C3A	C3I - C3A	C3J - C3A	C3K - C3A	C3I - C3C	C3J - C3C	C3K - C3C	C3J - C3I	C3K - C3I	C3K - C3J
Z	-2.461[a]	-1.182[a]	-1.144[a]	-1.464[a]	-1.805[b]	-1.895[b]	-.321[b]	-.404[a]	-1.001[a]	-1.077[a]
Asymp. Sig. (2-tailed)	.014	.237	.252	.143	.071	.058	.748	.686	.317	.282

a. Based on negative ranks.

b. Based on positive ranks.

c. Wilcoxon Signed Ranks Test

WilcoxonCost1

Reduce cost of inspection[c]

	C4I - C4C	C4J - C4C	C4K - C4C	C4J - C4I	C4K - C4I	C4K - C4J
Z	-.850[a]	-.486[a]	-.227[a]	-.156[b]	-.578[b]	-.426[b]
Asymp. Sig. (2-tailed)	.395	.627	.820	.876	.563	.670

a. Based on negative ranks.

b. Based on positive ranks.

c. Wilcoxon Signed Ranks Test

Reduce cost of labour[c]

	C5C - C5A	C5E - C5A	C5K - C5A	C5E - C5C	C5K - C5C	C5K - C5E
Z	-2.375[b]	-1.432[a]	-2.035[a]	-2.890[a]	-3.361[a]	-.604[a]
Asymp. Sig. (2-tailed)	.018	.152	.042	.004	.001	.546

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

To reduce cost of inventory[c]

	C6E - C6I	C6K - C6I	C6M - C6I	C6K - C6E	C6M - C6E	C6M - C6K
Z	-1.602[b]	-2.504[b]	-2.154[b]	-.992[b]	-.425[b]	-.757[a]
Asymp. Sig. (2-tailed)	.109	.012	.031	.321	.671	.449

a. Based on negative ranks.

b. Based on positive ranks.

c. Wilcoxon Signed Ranks Test

WilcoxonCost2

Reduce cost of materials[c]

	C7J - C7I
Z	-2.177[b]
Asymp. Sig. (2-tailed)	.029

b. Based on positive ranks.

c. Wilcoxon Signed Ranks Test

Reduce cost of scrap[c]

	C8I - C8H	C8J - C8H	C8K - C8H	C8J - C8I	C8K - C8I	C8K - C8J
Z	-2.064[b]	-2.361[b]	-2.489[b]	-.532[b]	-.395[b]	-.233[a]
Asymp. Sig. (2-tailed)	.039	.018	.013	.595	.693	.816

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

Reduce cost of work in progress[c]

	C9B - C9A	C9C - C9A	C9E - C9A	C9C - C9B	C9E - C9B	C9E - C9C
Z	-2.320[a]	-.522[b]	-1.131[a]	-2.535[b]	-.872[b]	-1.370[a]
Asymp. Sig. (2-tailed)	.020	.601	.258	.011	.383	.171

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

Reduce total operational cost[c]

	C10C - C10A	C10I - C10A	C10J - C10A	C10E - C10A	C10I - C10C	C10J - C10C	C10E - C10C	C10J - C10I	C10E - C10I	C10E - C10J
Z	-2.514[b]	-.808[b]	-.192[b]	-3.185[a]	-2.114[a]	-2.218[a]	-3.995[a]	-.402[a]	-2.837[a]	-2.215[a]
Asymp. Sig. (2-tailed)	.012	.419	.848	.001	.034	.027	.000	.688	.005	.027

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

Increase labour efficiency[c]

	C11H - C11A	C11C - C11A	C11I - C11A	C11K - C11A	C11C - C11H	C11I - C11H	C11K - C11H	C11I - C11C	C11K - C11C	C11K - C11I
Z	-1.601[a]	-2.676[b]	-1.670[b]	-1.761[b]	-3.995[b]	-3.028[b]	-3.249[b]	-1.163[a]	-1.069[a]	-.417[b]
Asymp. Sig. (2-tailed)	.109	.007	.095	.078	.000	.002	.001	.245	.285	.677

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

To increase machine efficiency[d]

	C12C - C12A	C12I - C12A	C12J - C12A	C12K - C12A	C12M - C12A	C12I - C12C	C12J - C12C	C12K - C12C	C12M - C12C	C12J - C12I
Z	-2.230[b]	-2.060[b]	-1.913[b]	-.606[b]	-.662[b]	-.032[b]	-.024[b]	-1.573[a]	-1.466[a]	.000[c]
Asymp. Sig. (2-tailed)	.026	.039	.056	.545	.508	.974	.981	.116	.143	1.000

WilcoxonCost4

To increase machine efficiency[d]

	C12K - C12I	C12M - C12I	C12K - C12J	C12M - C12J	C12M - C12K
Z	-1.433[a]	-1.641[a]	-1.667[a]	-1.591[a]	-.097[a]
Asymp. Sig. (2-tailed)	.152	.101	.096	.112	.923

a. Based on positive ranks.

b. Based on negative ranks.

c. The sum of negative ranks equals the sum of positive ranks.

d. Wilcoxon Signed Ranks Test

WilcoxonCost5

Wilcoxon Test Results - Quality

To reduce quality of rework[c]

	Q1I - Q1H	Q1J - Q1H	Q1K - Q1H	Q1J - Q1I	Q1K - Q1I	Q1K - Q1J
Z	-2.365[a]	-3.115[a]	-2.728[a]	-.829[a]	-.438[a]	-.690[b]
Asymp. Sig. (2-tailed)	.018	.002	.006	.407	.661	.490

a. Based on negative ranks.

b. Based on positive ranks.

c. Wilcoxon Signed Ranks Test

To reduce quantity of scrap[c]

	Q2J - Q2I	Q2K - Q2I	Q2K - Q2J
Z	-.916[a]	-.872[b]	-1.466[b]
Asymp. Sig. (2-tailed)	.360	.383	.143

a. Based on negative ranks.

b. Based on positive ranks.

c. Wilcoxon Signed Ranks Test

To increase yield[c]

	Q3H - Q3A	Q3I - Q3A	Q3J - Q3A	Q3K - Q3A	Q3I - Q3H	Q3J - Q3H	Q3K - Q3H	Q3J - Q3I	Q3K - Q3I	Q3K - Q3J
Z	-.763[a]	-2.528[b]	-2.066[b]	-1.124[b]	-3.339[b]	-3.190[b]	-2.839[b]	-.105[a]	-1.717[a]	-1.089[a]
Asymp. Sig. (2-tailed)	.445	.011	.039	.261	.001	.001	.005	.917	.086	.276

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

WilcoxonQuality1

To reduce defects per batch[c]

	Q4I - Q4H	Q4J - Q4H	Q4K - Q4H	Q4J - Q4I	Q4K - Q4I	Q4K - Q4J
Z	-3.685[a]	-3.074[a]	-3.124[a]	-1.098[b]	-1.687[b]	-.667[b]
Asymp. Sig. (2-tailed)	.000	.002	.002	.272	.092	.505

a. Based on negative ranks.

b. Based on positive ranks.

c. Wilcoxon Signed Ranks Test

To reduce rework labour[d]

	Q5I - Q5A	Q5J - Q5A	Q5K - Q5A	Q5J - Q5I	Q5K - Q5I	Q5K - Q5J
Z	-3.588[b]	-2.824[b]	-1.934[b]	-.072[b]	-1.781[a]	-1.528[a]
Asymp. Sig. (2-tailed)	.000	.005	.053	.943	.075	.126

a. Based on positive ranks.

b. Based on negative ranks.

d. Wilcoxon Signed Ranks Test

To reduce the number of inspecion activities[c]

	Q6J - Q6I	Q6K - Q6I	Q6K - Q6J
Z	-.561[b]	-2.553[b]	-1.404[b]
Asymp. Sig. (2-tailed)	.575	.011	.160

b. Based on positive ranks.

c. Wilcoxon Signed Ranks Test

WilcoxonQuality2

To reduce non-conforming product[c]

	Q7I - Q7H	Q7J - Q7H	Q7K - Q7H	Q7J - Q7I	Q7K - Q7I	Q7K - Q7J
Z	-3.610[b]	-3.295[b]	-3.456[b]	-.714[a]	-1.467[a]	-.691[a]
Asymp. Sig. (2-tailed)	.000	.001	.001	.475	.142	.490

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

WilcoxonQuality3

Wilcoxon Test Results - Flexibility

To reduce the lead-time to make a product[c]

	F1B - F1A	F1C - F1A	F1I - F1A	F1C - F1B	F1I - F1B	F1I - F1C
Z	-.863[a]	-1.412[b]	-.291[b]	-1.895[b]	-.662[b]	-1.396[a]
Asymp. Sig. (2-tailed)	.388	.158	.771	.058	.508	.163

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

•

To achieve a predictable output when conditions change[c]

	F3I - F3H	F3J - F3H	F3K - F3H	F3J - F3I	F3K - F3I	F3K - F3J
Z	-1.016[a]	-.897[a]	-1.832[a]	-.036[b]	-.193[a]	-.267[a]
Asymp. Sig. (2-tailed)	.310	.370	.067	.971	.847	.790

a. Based on negative ranks.

b. Based on positive ranks.

c. Wilcoxon Signed Ranks Test

To reduce changeover time[c]

	F4B - F4A	F4C - F4A	F4I - F4A	F4K - F4A	F4C - F4B	F4I - F4B	F4K - F4B	F4I - F4C	F4K - F4C	F4K - F4I
Z	-1.295[a]	-1.209[b]	-1.490[b]	-.777[a]	-2.623[b]	-2.355[b]	-.741[b]	-.047[b]	-2.430[a]	-2.299[a]
Asymp. Sig. (2-tailed)	.195	.227	.136	.437	.009	.019	.458	.963	.015	.021

a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

To reduce bottlenecks[c]

	F5B - F5A	F5C - F5A	F5E - F5A	F5L - F5A	F5F - F5A	F5C - F5B	F5E - F5B	F5L - F5B	F5F - F5B	F5E - F5C
Z	-.135[a]	-2.582[a]	-.354[a]	-.477[a]	-.442[a]	-2.195[a]	-.353[a]	-.642[a]	-.423[a]	-2.540[b]
Asymp. Sig. (2-tailed)	.893	.010	.723	.634	.659	.028	.724	.521	.672	.011

To reduce bottlenecks[c]

	F5L - F5C	F5F - F5C	F5L - F5E	F5F - F5E	F5F - F5L
Z	-1.839[b]	-2.435[b]	-.530[a]	-.179[a]	-.615[b]
Asymp. Sig. (2-tailed)	.066	.015	.596	.858	.539

a. Based on negative ranks.

b. Based on positive ranks.

c. Wilcoxon Signed Ranks Test

WilcoxonFlexibility2

Appendix 8

Additional suggestions offered by respondents

Additional suggestions offered in 'other' option on questionnaire

Additional suggestion / comment	Strategic	Mgmt.	Scope	Measure	People	Comment	Discuss
T1 Reduce Manufacturing Lead-time							
Lean manufacturing	✓						
Activities to customer – depends on activity – low effect low value						✓	
Activities to supplier – cumulative lead-time - then yes!!						✓	
Chart lead-time, reduce longest – repeat stock long lead-time parts				✓			
Reduce time/space availability on all processes – kanban paperwork		✓					
Resequencing reduces handoffs						✓	
Minimise Work in Progress				✓			
T2 Reduce Cycle Time							
Statistical Process Control		✓					
Supplier/Customer partnerships	✓						
Appropriate tooling, simplify set-up			✓				
Lot size = 1		✓					
Pace to constraint resource		✓					
Theoretical v actual times – eliminate delays				✓			
T3 Improve Lead-time Reliability							
Statistical Process Control		✓					
Supplier/Customer partnerships	✓						
Alternative routes – depending on route chosen – reliability can become worse						✓	
Measure lead-time – chart improvement				✓			
Make sure constraint resource is never down			✓				
Forecasting		✓					
Measure supplier performance				✓			
T4 Reduce Rework Time							
Concurrent engineering			✓				
Originator in charge of rework and added cost							
High capability process			✓				
Reduce batch size		✓					
Use IT or technology to enable activities essential							✓
Resources for error prevention						✓	
T5 Reduce Set-up Time							
Single Movement Exchange of Dies		✓					
Segregate internal/external activities	✓						
Simplify the assembly process			✓				
Error Proof							✓
T6 Reduce Inspection Time							
Move activities out of process to supplier							✓
Eliminate the need for inspection				✓			
In – process checking				✓			
Error logging/audit trail				✓			

Strategic: Strategic
Mgmt: Management and operation of process
Scope: Out of process scope
Measure: Measurement
People: People
Comment: General comment
Discuss: Justifies discussion

Additional suggestions offered in 'other' option on questionnaire

Additional suggestion / comment	Strategic	Mgmt.	Scope	Measure	People	Comment	Discuss
T7 Reduce Distance Travelled							
Store material at point of use							✓
One touch handling							✓
Design layout for lot size = 1							✓
Web technology	✓						
Cellular manufacture							✓
T8 Increase Output Rate							
Lean manufacturing	✓						
Share benefits of increased production with teams					✓		
Incorporate drum/buffer rope scheduling		✓					
Multi-skilling					✓		
Improve the design			✓				
C1 Cost of Rework							
Eliminate root causes			✓				
Find at earliest point to cause			✓				
Empower work team to eliminate root cause					✓		
Juran Quality Improvement Teams		✓					
Kaizen		✓					
C2 Increase Machine Productivity							
Productivity and efficiency are confounded beyond useful						✓	
Quick changeover				✓			
Preventative maintenance		✓					
C3 Increase Labour Productivity							
Self directed work teams					✓		
Group gainsharing					✓		
Use IT or technology to enable activities							✓
Scheduling – information availability		✓					
Training					✓		
Multi-skilling					✓		
Web technology	✓						
Reward must combine quality and productivity					✓		
C4 Reduce Cost of Inspection							
Eliminate the need for inspection				✓			
Eliminate variation at source – proof of quality as a process step			✓				
Have each person responsible for inspecting prior persons work		✓					
Statistical Process Control		✓					
Error log / audit trail				✓			
Regard as Non-value added – eliminate						✓	

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Additional suggestions offered in 'other' option on questionnaire

Additional suggestion / comment	Strategic	Mgmt.	Scope	Measure	People	Comment	Discuss
C5 Reduce Cost of Labour							
Eliminate unions	✓						
Go off shore	✓						
Import from a lower cost country	✓						
Use IT or technology to enable activities decrease the cost of labour							✓
Automate							✓
Redesignate to eliminate labour	✓						
C6 Reduce Cost of Invetory							
Reduce the number of parts in a product			✓				
Good forecasts		✓					
JIT / kanban		✓					
Lot size = 1		✓					
Reduce cycle time and lead-time				✓			
Cost value as lost interest to maintain inventory	✓						
C7 Reduce Cost of Materials							
Supplier partnerships	✓						
Activities to supplier – can increase material costs/decrease quality						✓	
Use international procurement – total cost to own	✓						
Redesign the part / product			✓				
Value engineering			✓				
Negate fiscal year buys	✓						
Cost production plan as part of contract	✓						
C8 Reduce Cost of Scrap							
Reduce root cause of scrap			✓				
Find at earliest point to cause			✓				
High capability processes			✓				
Waste identification and elimination				✓			
Empower team and reward for eliminating root cause					✓		
C9 Reduce Cost of Work in Progress							
Eliminate early release to work in progress		✓					
Just in Time / kanban		✓					
One touch handling		✓					
Single piece work flow / Lot size = 1		✓					
Cut cycle time				✓			
C10 Reduce Total Operational Cost							
Optimise total business process	✓						
Integrate supply chain from supplier to customer	✓						

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Additional suggestions offered in 'other' option on questionnaire

Additional suggestion / comment	Strategic	Mgmt.	Scope	Measure	People	Comment	Discuss
C11 Increase Labour Efficiency							
Cross train and empower					✓		
Productivity and efficiency are confounded beyond useful						✓	
Error Proof; improve quality							✓
Make the people or teams performing an activity responsible for it is a probable effect						✓	
C12 Increase Machine Efficiency							
Productivity and efficiency are confounded beyond useful						✓	
Preventative maintenance		✓					
Depends on the available machine time						✓	
Use multiple high reliability flexible machines			✓				
Q1 Reduce Quantity of Rework							
Eliminate root cause of rework			✓				
High capability processes			✓				
Staff training to get activities right first time					✓		
Q2 Reduce Quantity of Scrap							
Reduce root cause of scrap			✓				
Technology alone does not make change occur – people do						✓	
High capability processes			✓				
Reduce set-up/ changeover time				✓			
Provide training, correct tools, equipment and information	✓						
Q3 Increase Yield							
High capability processes			✓				
Statistical Process Control		✓					
Provide training, correct tools, equipment and information	✓						
Q4 Reduce Defects per Batch							
Include product and process design in problem solving	✓						
High capability processes			✓				
Statistical Process Control		✓					
Provide training, correct tools, equipment and information	✓						
Q5 Reduce Rework Labour							
Reduce root cause of rework			✓				
Eliminate root cause of rework			✓				
High capability processes			✓				

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Additional suggestions offered in 'other' option on questionnaire

Additional suggestion / comment	Strategic	Mgmt.	Scope	Measure	People	Comment	Discuss
Q6 Reduce the Number of Inspection Operations							
Reduce need for inspection				✓			
Eliminate inspection				✓			
Quality suppliers and processes			✓				
Audit trail / error log				✓			
Is the customer happy to pay for activities - if not eliminate	✓						
Q7 Reduce Non-conforming Product							
Use concurrent engineering			✓				
Know what the customer wants	✓						
Provide immediate self-check and feedback				✓			
Statistical Process Control		✓					
Provide training, correct tools, equipment and information	✓						
F1 Lead-time to Make a Product							
Reduce lot sizes		✓					
Sequence design priorities to lead-time of components – schedule		✓					
Don't see difference between this and producing product lead-time						✓	
Encapsulate new product in project management		✓					
Effective supply chain co-ordination	✓						
F2 Increase Range of Products							
Establish configure to order process			✓				
Build to standard, configure to order	✓						
Design for modularity – modular BOMs configurators	✓						
F3 Achieve Predictable Output							
People and intelligence adapt – evolve or die – build your staff					✓		
ERP major driver – but never saw Use IT or technology to enable						✓	
Lot size = 1		✓					
Lean manufacturing	✓						
F4 Reduce Changeover Time							
Single Movement Exchange of Dies works in most environments			✓				
Visibility of change	✓						
Don't see difference between this and set-up						✓	
F5 Reduce Bottle necks							
Reduce set-up time				✓			
Manage capacity to bottleneck load		✓					
Theory of Constraints		✓					
Line balancing		✓					
Continuous improvement	✓						

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Appendix 9

Validation material

Redesigning Your 'Make Product' Process

The next few pages contain information to help you when redesigning your 'Make Product' process. They introduce tools and matrices that can be used when configuring or reconfiguring the activities within the 'Make Product' process to achieve performance improvements. Changes such as the training of employees are not included.

To use the matrices you must have:

- An understanding of the principle of a process-based organisation
- An understanding of your 'Make Product' process
- A set of strategically derived and balanced performance requirements for your 'Make Product' process.

Thinking in 'Processes'

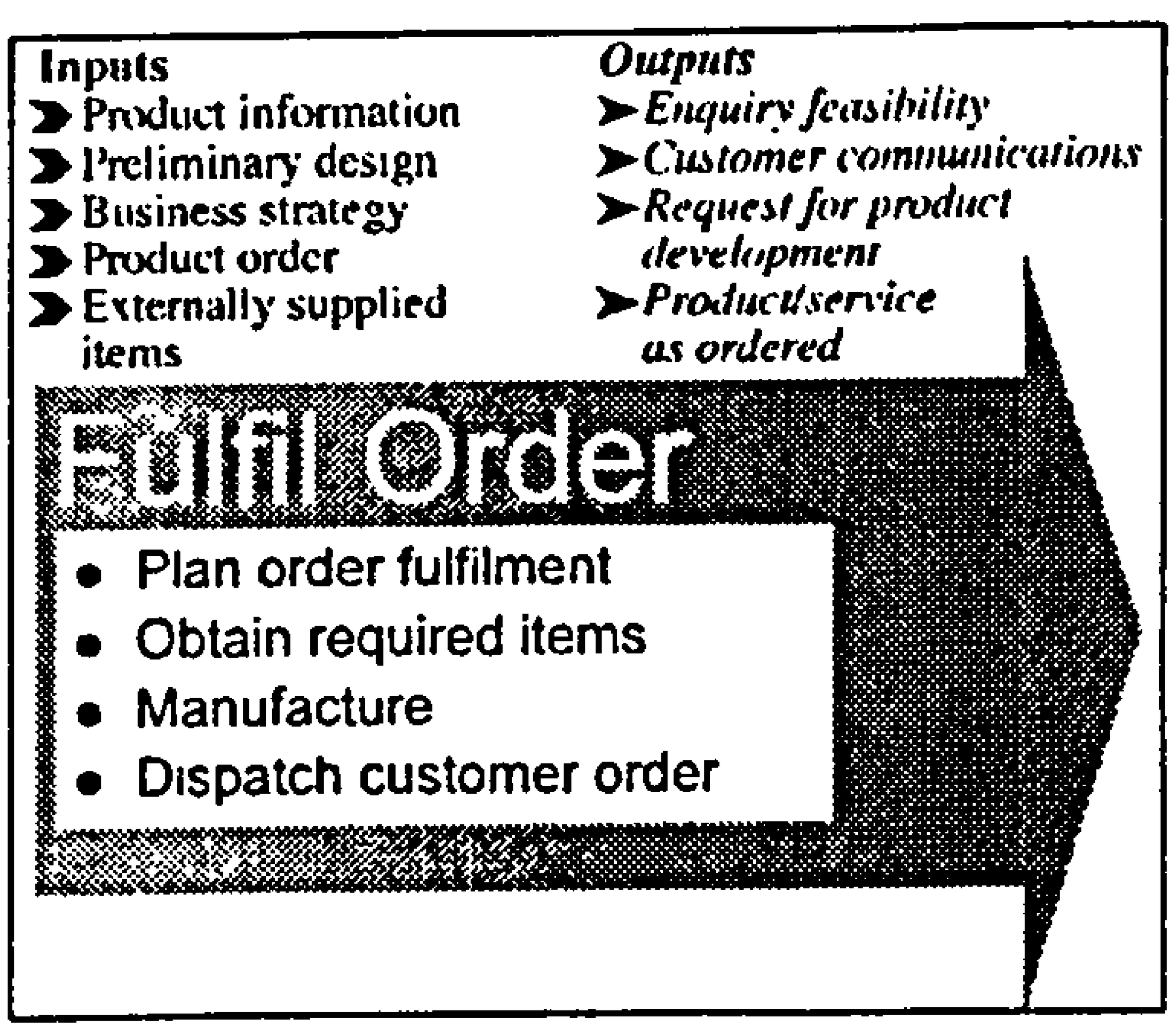
It is important that you understand the concept of business processes.

A business process encapsulates the interdependencies between tasks, roles, people and machines etc. that are required to provide a product or service (Earl, 1994). This includes the flow of materials, work and information through the process.

Business processes can be classified into three types, operate, support and manage.

There are four typical operate business processes: **develop product, get order, fulfil order and support product.**

The 'Fulfil Order' process can itself be split down into four generic processes, plan order fulfilment, obtain required items, manufacture and dispatch customer order (Weaver 1995).



The process by which you turn an order into a finished product or service by activities which are performed by your employees and your machines. Enquiries are turned into specifications, and product orders into products. This will include flow of materials and information that result in the fulfilment of an external customer's order or enquiry.

Taken from 'The Handbook for Process-Based Change' (2000)

These pages are concerned specifically with the redesign of the manufacture or 'Make Product' process. The 'Make Product' process contains the activities required to process work through manufacture from raw material to finished goods.

Your 'Make Product' Process

In order to make decisions as to whether the process improvement actions suggested in the matrices are applicable to your particular 'Make Product' process you should have some knowledge of your existing process.

The possible changes that can be made when redesigning a process are referred to as **Process Improvement Actions.** E.g. 'Performing activities in parallel'

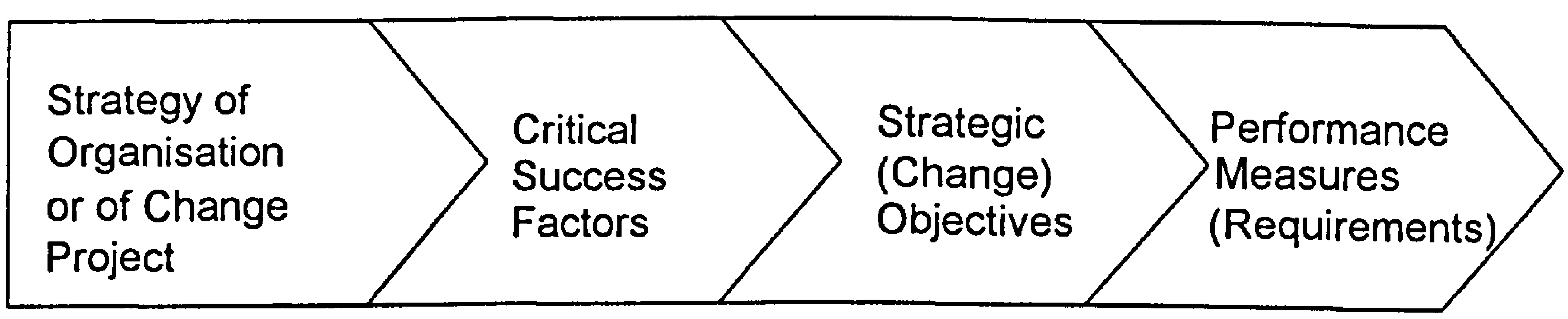
You do not necessarily have to have a model of your process at this stage but you should be aware of the purpose of your process and of the main stages and activities it encompasses.

Once you have used the matrices to identify the appropriate process improvement actions and are considering if or where in the process to implement them it will be beneficial to have a model of your 'Make Product' process.

Performance Requirements

The Performance Requirements that you develop for your 'Make Product' process drive the selection of process improvement actions from the matrices.

It is important that these performance requirements are developed in a structured manner and are derived from the strategy of the organisation or change programme. The stages in development are shown below.



The Development of Performance Measures

Strategic Change Objectives
Strategic Change Objectives are an explicit statement of your strategy and express what it is you want to achieve from the change project. They should be derived from the strategy of the organisation and balance the needs of the stakeholders and of the customers.

Critical Success Factors
It may not be clear from the change objectives which areas of performance are the most important. Critical success factors are the specific aspects of performance that must be improved in order to meet the strategic change objectives. They express what the strategic change objectives actually mean to the business.

Performance Measures
Performance Measures assess and monitor the performance of the business process in meeting the critical success factors and strategic change objectives. In the context of the matrices these Performance Measures equate to the Performance Requirements.

(Definitions adapted from The Handbook for Process-Based Change, 2000)

The performance requirements should be developed in such a structured way to ensure that they are in line with the strategy of the change or of the organisation. This will ensure that the changes made to improve the 'Make Product' process are in line with strategy.

The performance requirements should be balanced between the four dimensions of performance time, cost, quality and flexibility. This is to ensure that the process is not optimised in one dimension at the detriment of another.

Consideration should also be given to how the improvement of the 'Make Product' process may affect the other processes within the organisation. It should not be improved at the detriment of another process.

Tools to ensure that the performance requirements are developed in such a way are included in the Handbook for Process-Based Change (2000).

Using the Matrix
The redesign of your 'Make Product' process will require you to make changes to the process (implement process improvement actions). The redesigned process should result in improvements in the performance requirements that you specified for the process.

Selection of the appropriate process improvement actions is achieved through four matrices, one for each of the performance dimensions, time, cost, quality and flexibility.

The matrices show possible performance requirements for the 'Make Product' process and link these with suggested process improvement actions that, when implemented should improve them. The process improvement actions are ranked in the priority order that you should consider their implementation.

Definitions of the performance requirements and process improvement actions included in the matrices can be found in the appendices.

The performance requirements that appear in the matrices are some of the most common that are applicable to and can be directly improved by improvements in the 'Make Product' process.

If your performance requirement does not appear in the matrices it may be because:
- It cannot be improved by changes to the 'Make Product' process alone e.g. Despatch Reliability
- It is not a process level measure e.g. Profit

Before the matrices can be used in these cases the performance requirement must be broken down and expressed in terms of performance requirements that do appear in the matrices. Figure 1 and figure 2 will help you to do this.

> **Example:**
> Despatch Reliability does not appear in the matrices because it cannot be directly improved by making changes to the 'Make Product' process alone. Whilst the performance of the 'Make Product' process impacts on Despatch Reliability it is also strongly influenced by the scheduling of work.
>
> There are many aspects of performance within the 'Make Product' process that affect delivery performance but the key one could be considered to involve the flow of work through the process.
>
> Using figure 2 it can be found that manufacturing lead-time, cycle-time and lead-time reliability are the performance requirements that appear in the matrices and are concerned with the flow of work through the process.
>
> These can then be used in the time matrix to identify the process improvement actions that when implemented in the 'Make Product' process should contribute to the improvement of Despatch Reliability.
>
> If you decide that manufacturing lead-time is the most appropriate performance requirement then the time matrix suggests Eliminate Non-value Adding Activities, Reduce the Number of Activities and Perform Activities in Parallel.

The process improvement actions that appear in the matrices are suggested process improvement actions for performance requirements.

Taking each of the suggested process improvement actions in turn you should consider their implementation in your process. This should include consideration of where and how you might implement them and if they are sensible and appropriate to your particular process. You may for example choose not to implement the number 1 process improvement action but move onto the next. If you do not already have one a model of your 'Make Product' process will help with this.

Descriptions of the process improvement actions are included with the matrices to provide guidance and extra information when considering the implementation of the suggested process improvement actions for your process.

References

Childe S J, Maull R S, Smart P A, Rogers T J, Greswell T J, Wood C L, Radnor Z (2000) Handbook of process-based change, University of Plymouth

Earl M J (1994) 'The new and old business process redesign, Journal of Strategic information Systems, V3 N4

Weaver A M (1995) 'A model based approach to the design and implementation of computer aided production management systems.' PhD thesis University of Plymouth

Figure 1 - Considering the Performance Requirements for your Process....

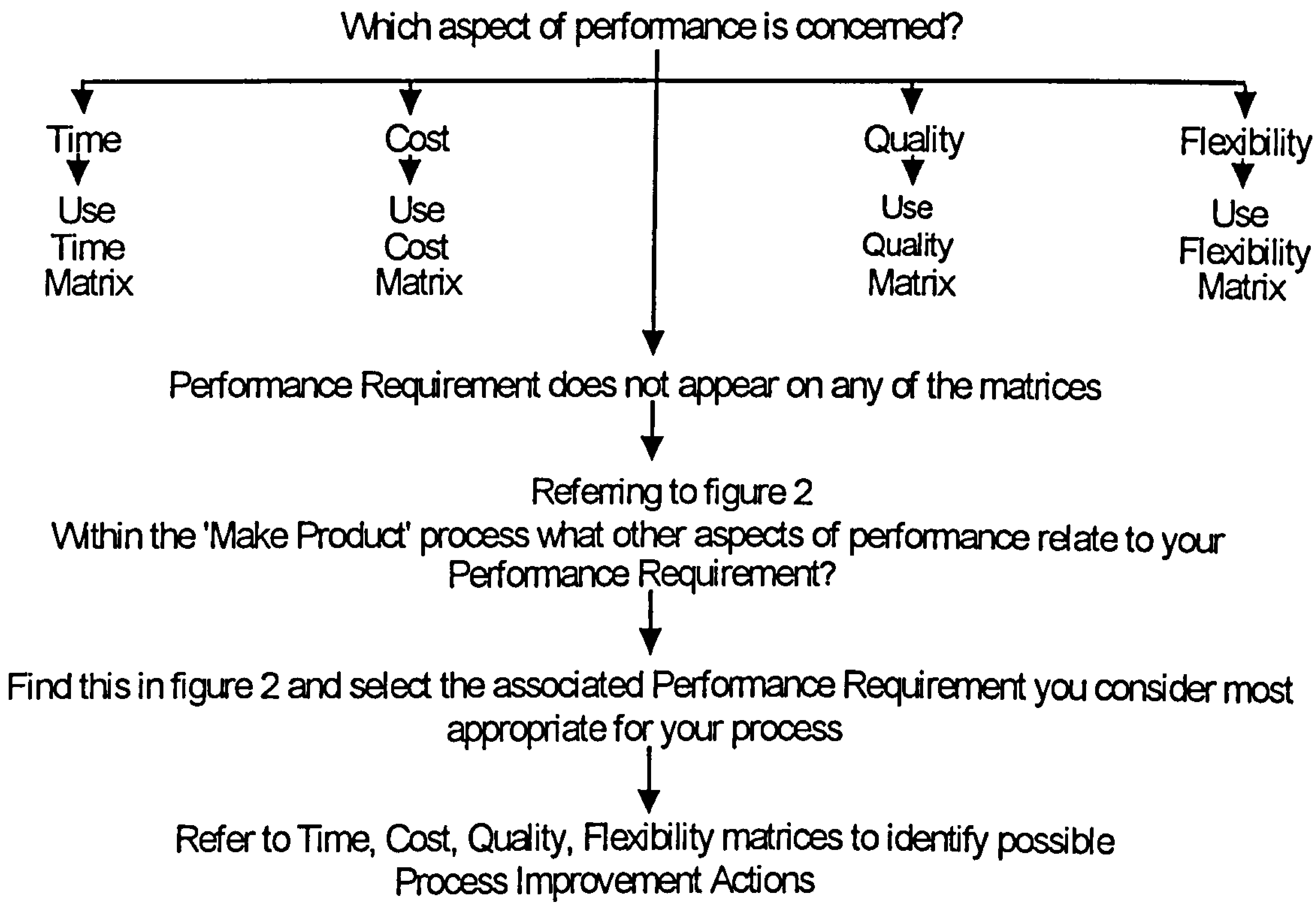


Figure 2 - Relating Your Performance Requirement to the Matrix

What aspect of performance does your Performance Requirement concern?	Performance Requirement on Matrix
Time	
Flow of work through the process	Manufacturing Lead-time Cycle Time Lead-time Reliability
Setting up of the work	Set-up Time
Physical distance that the work travels	Distance Travelled
Time taken to address quality issues	Rework Time Inspection Time
Output from process	Output Rate
Cost	
Costs incurred in addressing quality issues	Cost of Rework Cost of Scrap Cost of Inspection
Output of machines/people	Machine Productivity People Productivity Machine Efficiency People Efficiency
The cost of a particular aspect of the process	Labour Costs Total Operational Costs Material Costs
Costs incurred due to product in process	Cost of Work in Progress Cost of Inventory
Quality	
Quantity of non-conformance	Quantity of Scrap Quantity of Rework Defects per Batch Rework Labour Non-conforming Labour
Quantity of quality monitoring	Number of Inspection Operations
Flexibility	
Flow of work through the process	Lead-time to Make Product
Predictability of process in changing circumstances	Predictable Output
Time to change between products	Changeover Time
Hold-ups in process	Bottlenecks

The Matrices

M1: Time Matrix

Performance Requirements \ Process Improvement Actions	Eliminate NVA	Reduce Number of Activities	Perform Activities in Parallel	Make People Responsible	Standardise	Error Proof	Use Information Technology	Resequence Activities
Manufacturing Lead-time	❶	②	③					
Cycle Time	❶	②	③					
Lead-time Reliability				❶	②	②	③	
Output Rate	❶	❶	③	②	❶			
Set-up Time	②	③		③	❶			
Inspection Time				❶	❶	❶		
Rework Time		②		❶	❶	❶		
Distance Traveled	❶	❶						②

❶ ② ③ } Suggested order for implementation of Process Improvement Actions

M2: Cost Matrix

Performance Requirements \ Process Improvement Actions	Eliminate NVA	Reduce Number of Activities	Perform Activities in Parallel	Make People Responsible	Standardise	Error Proof	Use Information Technology	Case Manager	Move Activities to Supplier
Cost of Rework		②		❶	❶	❶			
Cost of Inspection	❶			❶	❶	❶			
Cost of Scrap				❶	❶	❶		②	
Machine Productivity	❶	③		②		②			
Machine Efficiency	❶	③		②	❶	❶	②		
Labour Productivity	❶	③		②	②	②			
Labour Efficiency	❶	③		②	②			③	
Cost of Labour	❶	②		③					③
Total Operational Cost	❶	②			②	②			③
Cost of Material					❶	②			
Work in Progress	❶	❶	③						②
Inventory				③	❶		③		②

❶ ② ③ } Suggested order for implementation of Process Improvement Actions

M3: Quality Matrix

Performance Requirements \ Process Improvement Actions	Reduce Number of Activities	Make People Responsible	Standardise	Error Proof	Case Manager
Rework Quantity		❶	❶	❶	②
Rework Labour	③	②	❶	❶	
Yield	③	②	❶	❶	③
Defects per Batch		❶	❶	❶	②
Non-conforming Product		❶	❶	❶	②
Quantity of Scrap		❶	❶	❶	
No. of Inspection Operations		③	❶	②	

❶ ② ③ } Suggested order for implementation of Process Improvement Actions

M4: Flexibility Matrix

Performance Requirements \ Process Improvement Actions	Eliminate NVA	Reduce Number of Activities	Perform Activities in Parallel	Make People Responsible	Standardise	Error Proof	Create Alternative Routes	Case Manager	Resequence Activities	Move Activities to Supplier
Lead-time to Make Product	❶	❶	❶		❶					
Predictable Output				❶	❶	❶		❶		
Changeover Time	❶	②	③	③	❶					
Bottlenecks	❶	③	③				②		③	③

❶ ② ③ } Suggested order for implementation of Process Improvement Actions

Feedback Comments Questionnaire
Your Business Process Redesign Experience

Are you currently participating in any Business Process Redesign projects?

Yes [ ] No [ ]

How many Business Process Redesign projects have you been involved in?

0 [ ] 1-3 [ ] >3 [ ]

Did any of them concern the 'Make Product' process?

Yes [ ] No [ ]

The Business Process Redesign Method

.	*Comments regarding specific questions can be made under the question or at the end of the questionnaire*	Strongly Agree	Agree	Neither	Disagree	Strongly Disagree
1	The process improvement actions suggested for each of the performance requirements presented in the matrices are essentially correct					
2	The performance requirements and process improvement actions included in the matrices represent those applicable to a 'Make Product' process					
3	It would be easy to use the matrices when redesigning a 'Make Product' process					
4	I understand how to use the matrices when redesigning a 'Make Product' process					
5	It would be easy to use the matrices, even when the selected performance requirement does not appear on them					
6	I understand how to use the matrices when the selected performance requirement does not appear on them					
7	The matrices would help in selecting the appropriate process improvement actions to implement when redesigning a 'Make Product' process to achieve specific performance improvements					
8	There is sufficient supporting information to understand the context of business process redesign into which the approach fits					
9	I understand the concept of a business process as described in the supporting information					
10	It is important to develop performance measures in line with the strategy of the organisation					

	Comments regarding specific questions can be made under the question or at the end of the questionnaire	Strongly Agree	Agree	Neither	Disagree	Strongly Disagree
11	It is important to use strategically derived performance requirements when redesigning business processes					
12	Deciding on the process changes to make when redesigning the 'Make Product' process would be easy using this approach					
13	Using this approach for business process redesign would encourage companies to consider the performance requirements of a 'Make Product' process throughout redesign					
14	I would use this approach if involved in a project to redesign a 'Make Product' process					
15	I would have difficulties in using the approach					
16	It is important to redesign business processes to achieve specific performance improvements					
17	It is important to redesign business processes to meet strategically derived performance requirements					
18	This approach could be used in other companies to help in business process redesign projects					
19	The approach helps in understanding the role of strategically derived performance measures within business process redesign					
20	We are currently undertaking a business process redesign project involving the 'Make Product' process within the company					
21	Using this approach would help to improve our current business process redesign practices					
22	This approach would help to structure a redesign project					
23	The matrices can be used to trigger further ideas as to process changes to make					
24	It is important to have balanced performance requirements for the 'Make Product' process					
25	It is important to take a holistic view when redesigning business processes					
26	I have seen the links between performance requirements and process improvement actions for the 'Make Product' process established and stated elsewhere. ***Please say where...***					

Overall Comments

Please make any comments you feel appropriate

Please make any further comments regarding individual questions

What developments, changes, improvements would you like to see?

About Yourself

Name:

Position in company:

Nature of company business:

Appendix
Process Improvement Actions

Eliminate non-value adding activities
Activities that are redundant, duplicated, outdated or driven by bureaucracy do not add value to a process. If these activities truly have no value within the process they should be eliminated.

Activities can be classified into three types:
Real value added – those that add value for the customer
Business value added – those that add value for the business
Non value added – those that add no value at all

Looking at the activities within the process aim to minimise those that only add value for the business such as maintaining personnel records and aim to eliminate those that have no added value such as storage or approvals.

Activities that are duplicated or redundant and any unnecessary checks and controls that have no role in the process should be eliminated.

Reduce the number of separate activities within a process
Integrating separate activities or eliminating duplicate activities within a process can reduce the number of individual activities in the process. This will reduce the number of interfaces and hand-offs within the process.

If the number of activities within a process is minimised then so the number of handoffs and thus potential for delays and errors is reduced.

The activities within the process should be considered looking for opportunities to aggregate successive activities or to aggregate activities with any decisions made regarding those activities. A reduction in the number of activities can also be achieved through the elimination of non-value adding activities as detailed above.

Perform activities in parallel or concurrently
Activities within a process that are not dependent upon each other can be performed in parallel or concurrently. For example, the manufacture of two sub-components that are to be assembled into a final product need not be performed sequentially, but in parallel. Work may also be conducted concurrently by separate parts of a process and then integrated together as in the case of concurrent engineering.

Look at the activities currently performed in sequence in your process and check for dependency.

Standardise
All procedures and documentation regarding a process should outline the best method of performing the activities within the process and the process overall. These should be standardised so that all can understand them.

Error proof
Design your processes or look at the design of existing processes and change them so that there is only one way to perform them and therefore it is difficult or impossible to make mistakes or errors.

Re-sequence activities
The sequence in which activities are performed can be changed. These activities may, or may not be geographically dispersed. Re-sequencing activities should make the movement of work through the process as efficient as possible.

Make the people or teams performing the activities responsible for the activity
Where an activity, such as purchasing or inspection is moved back into a process then the work involved in completing that activity becomes the responsibility of the people within the process. This requires, particularly in the case of control and checking type activities that the people within the process take greater responsibility and make any decisions required. Increased responsibility can also be given to those performing the process through the use of self-managed teams.

To take advantage of this the decision points have to be put in the process along with the activity to which they apply. If this responsibility is given to the people in the process then they must also be given the authority to make those decisions.

Introduce a case manager, caseworkers or case team
A case manager acts as a single point of contact for the customer regarding a process and has access to all information regarding the process. Where the number of separate activities has been reduced by integration or elimination, an individual or a team can be used to perform the process and manage any remaining interfaces and hand-offs. This person or team can be referred to as a caseworker or case team.

If activities cannot be integrated then a Case Manager can manage the interfaces and hand-offs as well as acting as a single point of contact.

Move activities out of the process
Activities that are performed by a process can be moved out of the process internally to another process or to someone external to the organisation.

They can be moved out of the process to the suppliers of the process. For example a company may insist upon quality assured inputs that do not need further inspection or get a supplier to assemble some sub-components prior to delivery.

Create multiple routes or paths through the process

Rather than pass standardised work and specialised work through the same process and have standard work queuing behind specialised work consider creating separate processes or separate process paths for each. In the case of separate process paths work may first be subject triage checking for complexity, volume etc. and deciding which route it should take through the process.

Use Information Technology (and technology) to enable activities and processes
Technology or information technology can be used to undertake an activity or process. For example, if a human performs an activity, the human can be replaced and the activity performed by a machine.

Information technology or technology can also be used merely to support another process improvement action or the performance of an activity.

The enabling potential of IT can be summarised as:
Automational: Eliminating humans from the process
Informational: Capturing process information
Sequential: Changing process sequence or enabling parallel processing
Tracking: Monitoring processes and objects
Geographical: Co-ordinating across distances
Integrative: Co-ordinating tasks and processes
Intellectual: Capturing and distributing intellectual assets
Disintermediating: Eliminating intermediaries

Performance Requirements

Time

Manufacturing Lead-Time
The total time taken between receipt of an order by manufacturing and them satisfying that order.

Cycle Time
The time taken to complete one cycle of a process including processing, moving, waiting, inspection and set-up time.

Lead Time Reliability
The extent to which the lead times taken to undertake the work is consistent and so predictable.

Rework Time
The time spent rectifying work that was produced incorrectly or was defective the first time.

Set-up Time
The time that it takes to perform the activities required to set-up machines or prepare to undertake work within a process.

Inspection Time
The total time that it takes to perform the inspection, checking and monitoring activities within a process.

Distance Travelled
The distance that work travels whilst been progressed from the start to the finish of the process.

Output Rate
The rate at which completed work emerges from the process e.g. 100 parts per hour.

Cost

Labour Productivity
A comparison of the quantity of work completed against the actual time taken to complete it.

Machine Productivity
A comparison of the quantity of work produced by a machine against the total number of hours the machine was running to produce it.

Cost of Rework
The cost of rectifying the work produced that does not meet specification or is defective.

Cost of Scrap
The cost of the scrap resulting from the process, particularly work completed incorrectly or not meeting specification that must be thrown away.

Cost of Labour
The overall cost of the labour required operating the process and generating the required output.

Cost of Inventory
The cost of the inventory within a process including raw material, work in progress and finished goods.

Cost of Material
The cost of the raw material consumed by the process in order to generate the required output.

Cost of Inspection
The cost of the activities within the process concerned with the inspection, monitoring and checking of work.

Cost of Work in Progress
The cost of the work that is been worked on by the process (in progress).

Total Operational Cost
The total cost incurred in operating the process.

Labour Efficiency
A comparison of the actual hours taken to produce work against the standard hours budgeted to produce it.

Machine Efficiency
A comparison of actual machine hours taken to produce work against the standard machine hours budgeted to produce it.

Quality
Rework Quantity
The amount of the work produced that does not meet specification or is defective and must be reworked to rectify it.

Scrap Quantity
The amount of scrap resulting from the process, particularly work completed incorrectly or not meeting specification that must be thrown away.

Yield
The amount of the work produced that when subject to test (against specification) passes.

Defects per Batch
The number or percentage in a batch that do not meet specification or are defective.

Rework Labour
The extra labour required rectifying work that was produced incorrectly or was defective the first time.

Number of Inspection Activities
The number of activities within the process that are concerned with the inspection checking or monitoring of work.

Non-conforming Product
The percentage of the work produced that does not conform to the original specification set for it.

Flexibility
Lead time to make Product
The total time taken between receipt of an order by manufacturing and them satisfying that order.

Range of Products
The number of different products or outputs the process is capable of generating.

Predictable Output when Conditions Change
Consistency of output when conditions change such as absenteeism, breakdown etc.

Changeover Time
The time required changing the process over from production of one product or output to a different product or outcome.

Bottlenecks
The number of activities within a process at which queues occur and work is held up.

Appendix 10

Summary of the feedback comments questionnaire

Summary of the Feedback Comments Questionnaire
Your Business Process Redesign Experience

Are you currently participating in any Business Process Redesign projects?

Yes [11] No [3]

How many Business Process Redesign projects have you been involved in?

0 [ ] 1-3 [4] >3 [10]

Did any of them concern the 'Make Product' process?

Yes [12] No [2]

The Business Process Redesign Method

	Comments regarding specific questions can be made under the question or at the end of the questionnaire	Strongly Agree	Agree	Neither	Disagree	Strongly Disagree
1	The process improvement actions suggested for each of the performance requirements presented in the matrices are essentially correct	2	12			
2	The performance requirements and process improvement actions included in the matrices represent those applicable to a 'Make Product' process	4	10			
3	It would be easy to use the matrices when redesigning a 'Make Product' process	3	8	3		
4	I understand how to use the matrices when redesigning a 'Make Product' process	4	9	1		
5	It would be easy to use the matrices, even when the selected performance requirement does not appear on them	2	4	4	3	1
6	I understand how to use the matrices when the selected performance requirement does not appear on them					
7	The matrices would help in selecting the appropriate process improvement actions to implement when redesigning a 'Make Product' process to achieve specific performance improvements	5	8	1		
8	There is sufficient supporting information to understand the context of business process redesign into which the approach fits	2	9	1	2	
9	I understand the concept of a business process as described in the supporting information	6	7	1		
10	It is important to develop performance measures in line with the strategy of the organisation	14				

	Comments regarding specific questions can be made under the question or at the end of the questionnaire	Strongly Agree	Agree	Neither	Disagree	Strongly Disagree
11	It is important to use strategically derived performance requirements when redesigning business processes	11	3			
12	Deciding on the process changes to make when redesigning the 'Make Product' process would be easy using this approach	3	9	1	1	
13	Using this approach for business process redesign would encourage companies to consider the performance requirements of a 'Make Product' process throughout redesign	3	7	3		1
14	I would use this approach if involved in a project to redesign a 'Make Product' process	1	12	1		
15	I would have difficulties in using the approach			4	9	1
16	It is important to redesign business processes to achieve specific performance improvements	9	5			
17	It is important to redesign business processes to meet strategically derived performance requirements	8	6			
18	This approach could be used in other companies to help in business process redesign projects	2	12			
19	The approach helps in understanding the role of strategically derived performance measures within business process redesign	2	7	4	1	
20	We are currently undertaking a business process redesign project involving the 'Make Product' process within the company	2	2	4	6	
21	Using this approach would help to improve our current business process redesign practices	1	9	4		
22	This approach would help to structure a redesign project	1	12	1		
23	The matrices can be used to trigger further ideas as to process changes to make	5	9			
24	It is important to have balanced performance requirements for the 'Make Product' process	6	6	1	1	
25	It is important to take a holistic view when redesigning business processes	9	4	1		
26	I have seen the links between performance requirements and process improvement actions for the 'Make Product' process established and stated elsewhere. ***Please say where...*** 2 respondents did not answer this question	3	6	2	1	

Overall Comments

Please make any comments you feel appropriate

- It looks like a good set-up
- Good work. Can add something that the objectives have been achieved for top management (before and after re-design)
- Similar matrices could be used in engineering and administration too
- I'll use it in my next project
- The matrix provides good guidelines but practitioners still need to be familiar with the Process Improvement Actions
- Should never limit the potential to 'Make' only
- Good summary, the matrices provide a concise presentation of some good strategies and where to apply them
- This could be considered as help but not as a guide. It did not cover all of the topics I consider when re-designing
- I missed the planning and internal planning and scheduling process in the matrices and the management of the process (supply of raw materials, kanban, push feed etc.)
- The thinking behind the approach is not new but the structured approach whereby different elements are prescribed for different courses of action is novel. It would be useful to give direction to the team embarking on a change process
- Make order indicators clearer
- Your work is very scholarly and quite sound I believe
- There should be more inclusion of the affect of design changes on the 'Make Product' process
- Overall I feel that this paper would give companies considering process re-design a roadmap on how to approach the subject
- What do you mean by a Case Manager?

Please make any further comments regarding individual questions

- Reducing lot sizes (approaching n=1) is a strong strategy for improving all aspects of the 'Make Product' process and has a strong influence over the performance of the 'Order Fulfilment' process
- Elimination of non-value-adding activities is important and can make major contributions to improving quality
- Involve labour force early in process re-design
- Ref 26: Initially the link between Performance Requirements and process ought to be reflected in the Business Strategy and plans, the project plan and improvement teams charter should reflect specific performance goals

What developments, changes, improvements would you like to see?

- I would advise that you connect certain statements to accepted models in the market place
- Communication is critical in re-design, this practical approach gives that communication and assurance of meeting project objectives
- Projects benefit from a team approach (champions, players, facilitators)
- Strategic objectives, detailed plans, simple measures, coaching and facilitation add up to successful completion of a project
- Cost of WIP and inventory are not results of the 'Make Product' process but are influenced by scheduling and in the case of inventory by material acquisition policies
- Increase scope to include other processes inside the company
- As some common actions are dominant consider evolving the handbook into a set of areas to be reviewed and a recommended sequence of approach for use in all cases, followed by specific actions depending on which performance dimension dominates
- Non-value- added activity elimination is the most important part of re-design, however many people do not understand the concept. Perhaps you could add some more examples of NVA activities

Appendix 11

Conference papers