THE DEVELOPMENT OF A PERFORMANCE MEASUREMENT METHODOLOGY IN SUPPORT OF THE NEW PRODUCT INTRODUCTION PROCESS

by

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Abstract

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This thesis describes the application of a performance measurement method in New Product Introduction (NPI). The NPI process is important in any business context as a result of constant competition and market globalisation. Delays in the NPI process are likely to compromise organisations' profitability. Time-to-market is therefore a crucial business success factor. To control a product's time-to-market the NPI process needs to be managed effectively through the use of process performance measures. Through the initial literature research it became apparent that there are no appropriate measures to specifically assess the NPI process. Those, which are typically used, tend to be of a financial nature based on outcome that does not provide process-related information.

This research makes a unique contribution to knowledge by the development of a NPI performance measurement method that is predictive. The case study carried out showed that this method allows practitioners to dynamically monitor and improve the output of the NPI process. The method proposed has a general application within a wide range of companies as indicated by the analysis of data provided by the survey and the case study carried out. The main step of the methodology concentrates on a set of value indicators developed by the author that measure the effect of delays on a number of key variables. The appropriate application of this methodology will improve the NPI process and consequently it's time-to-market.

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The author joined the school of Aerospace Automotive and Design Engineering at the University of Hertfordshire to research and develop a performance measurement method for the New Product Introduction process. Petros Khoudian (Principal Supervisor), Dave Pearce and Ian McAndrew supervised the research into the application of performance measurement to the process of New Product Introduction. The author would therefore like to express her gratitude to the supervisory team and thank all of them for the many hours spent reading and rereading chapter drafts. Their insights and comments were often challenging but always constructive and helpful. I am also grateful to other researchers who were involved with the project at various times during its development and helped to sustain momentum.

Thanks are also expressed to Tom Page and late Jim O'Sullivan for their efforts and support. Tom moved on from University of Hertfordshire but still offered his support where possible.

The empirical work contained in this thesis would not have been possible without the co-operation of many industry practitioners of NPI. The author is particularly grateful to the companies (Appendix 1) who participated in case studies, and the individuals who gave up their time to be interviewed.

In particular thanks are due to employees of the companies that participated in this research, past and present, who offered moral support and encouragement throughout this endeavour. Finally, the author would like to thank her close family for their support and understanding throughout these demanding years.

Chapter 1

1. INTRODUCTION

1.1 Background

Historically, companies launch new products to their respective markets using varied methods and procedures. Over the years, customer expectations, market globalisation and constant competition have limited the margin for development errors and delays in the introduction process. This has resulted in companies focusing on their New Product Introduction (NPI) process and in particular its duration to improve competitive performance.

One of the companies that were studied throughout this research project (Company A, Appendix 1) faces external pressures and required a review of the existing processes around the development and introduction of new products. After interviewing key personnel the author identified that the company needed to introduce an improvement project to define a new process with features that would improve the performance of the overall company.

This research programme has originated from the desire to assist organisations such as Company A and others with similar pressures as well as practitioners in general with the monitoring and control of their NPI processes. By doing so companies can act based on process data in order to minimise and where possible eliminate process delays.

The review of the literature and the sponsor company's data and experience established that there was a need for a performance measurement method to be developed for the purpose of assessing the NPI process.

This thesis contains the research carried out by the author to verify the need for a performance measurement method for the NPI process and its development.

1.2 Aims and Objectives

The aim of this research is to determine the extent, in terms of both theory and practice, to which a performance measurement method specifically developed for the NPI process can be utilised to monitor the process and subsequently reduce process costs and time to market.

The key questions driving the research encompass both theory and practice. These questions are:

Q1: To what extent is performance measurement being applied within the NPI process.

Q2: To what extent could performance measurements be applied within the NPI process.

The objectives are to:

- establish a methodology to enable practitioners to monitor and measure the performance of the NPI process.

- determine the value indicators that would be used to assess the performance of the NPI process.

- identify different company characteristics that may influence the application of the method proposed.

1.3 Introduction

This thesis investigates the application of performance measurements in the NPI process.

For the purpose of this investigation, "*performance measurement is defined as the process of quantifying the efficiency and effectiveness of a process*" (Neely et.al., 1995). New product introduction is taken as referring to the process by which new products are developed in companies, from the conception of an idea until the product is launched into the market. Performance measurement can be utilised while improving both products and processes. While much has been written on performance measurement in general this thesis is concerned with the detailed performance measurement of the process of NPI, an area which is relatively uncharted.

It should also be noted that the phrase "performance measurement" refers not only to the measurement of processes but also to the measures and systems that supports it.

Performance measurement is necessary because it provides a systematic approach to evaluating the efficiency of a process. The analysis of the measurements used can derive useful information for corrective action. Performance measures that act as predictive indicators, that can be used throughout the duration of a process rather than when the process is complete, prove to be even more useful since poor performance can be addressed at an earlier stage.

The thesis bridges the domains of performance measurement and NPI by developing an analytical model which can be used to aid the application of performance measurement within the NPI process. There are two main stages in the methodology developed by the author. First, the methodology is defined in a theoretical context. Then the data obtained using a variety of research methods (preliminary interviews, survey, follow up interviews, case study) is applied to illustrate the application of the model employed in practice.

The rest of this chapter will review the current context for NPI, focusing on the need for improved performance. An overview of the structure of the thesis is also provided.

1.4 The current context of New Product Introduction

One of the most important business processes in an organisation is the process by which products/services are conceived, developed, and produced. This process is commonly called the New Product Introduction (NPI) process. It is vital for companies to realise the importance of this process and invest resources in developing the most efficient sequence of events that will make the product/service a success.

The author believes and Gardiner et.al. (1996) support that there is no standard NPI process that can suit all businesses. Different processes have evelved for different industries, according to their particular needs.

However, some similarities do exist and most generic processes follow the same pattern.

To continuously improve a process it is important that the process is reviewed on an ongoing bases. For that reason an effective NPI process should not be static, it should change and become more flexible to maintain market competitiveness. Interestingly, although the need for an established NPI process is recognised, according to a survey carried out by Griffin in 1997, a large number (40% of those surveyed) of firms still use no formal process for managing the introduction of new products to their markets. This gap in the business management system that exists from the lack of a formal process is easily recognised (Griffin, 1997; Rosas-Vega et al, 2000; Boardman et al, 2001; Wong, 2002; May-Plumlee, 2006). The author also identified the lack of a NPI process within the companies (Company A and B, Appendix 1) that participated in the fact finding preliminary interviews.

There is a significant amount of literature covering the NPI process (Wilson, 1996; Wheelwright et al, 1992; Trott, 1998; Shepherd et al, 2000, Pitiglio et al, 1992; Mahajan et al, 1992; Hart, 1996; Copper, 1986; Collins et al, 2002 and others). Much of the research into NPI over the last 20 years has looked at product success, i.e. what makes a successful product in terms of both its attributes and process/programme management (Johne and Snelson, 1988; Cooper, 1992), and considering innovation at the level of the organisation (Pavitt, 1991). In an attempt to meet the challenges faced by NPI, researchers have addressed particular aspects of NPI such as project management, communication, rapid prototyping and simultaneous engineering (Pearson and Ball, 1993; Moenaert and Caeldries, 1996; Costanzo, 1993; Pawar and Riedel, 1993; Swink et al., 1996)

There has also been an increasing recognition of the need to think of development activities in terms of a process (Davenport, 1993; Thomas, 1993; Wheelwright and Clark, 1992). Cooper and Kleinschmidt (1993) conclude that process, rather than external forces like market place and competition, "*dominates the success equation*". The author supports the view that the process itself is of paramount importance and that it should be flexible enough to cater for any market changes and increased competition.

The literature on NPI processes concentrates upon templates or blueprints for NPI and covers a wide range of approaches, from phase review to stage gate to overlapping and parallel processing models (Saren, 1984; Cooper, 1998; Cooper, 1994; Cooper and Kleinschmidt, 1993; Imai, Nokata et al., 1985; Thomas, 1993; Hart, 1995). Cooper (1994) looks beyond structures to the implications these more flexible and complex processes have in term of, for example, risk taking, wider participation in decision making, and learning.

Many firms have been relatively slow to pick up on the messages about the importance of NPI. Cooper and Kleinschmidt (1993) found that a minority of firms used a formal process or "stage-gate" system, while the Product Development and Management Association's 1990 survey revealed that only 54.5% of the firms surveyed had a well-defined NPI process (Page, 1993) increasing to around 60% by 1995 (Griffin, 1997). An increase on that percentage to 87.5% is also observed in a survey carried out by author in 2003 based on company responses. The details of this survey can be reviewed in chapter 7. Even amongst companies that do follow a process for NPI there is room for improvement. Cooper and Kleinschmidt (1993) claimed that "*...there are serious deficiencies in the typical firm's new product process*".

1.4.1 The need to improve the New Product Introduction process

Those involved with the NPI process, whether they cover specific tasks or phases within it, are under increasing pressure to improve the performance of the process. This is due to increased competition and market expectations that are influenced by the current globalisation trends (Rosas-Vega et al, 2000). The nature of the improvement required varies between companies.

However, the typical essential drivers and objectives that could lead to higher profitability (Cooper, 1994; Chen et al, 2001), a company's ultimate target, include:

- Reduction in time to market.
- Reduction in development costs.
- Increase in product design quality.
- Innovative designs.

Over the years academics have addressed the question of how to be more successful at developing and introducing new products to the market, as well as how to improve particular activities within the NPI process. However, it takes time for research findings to influence practice. Barclay (1992) found that very few companies knew about, or had applied, the findings from research studies carried out into the NPI process since the 1950s. Thus the need to improve the NPI process remains. The need for improvement increases as competitive pressures continue to escalate.

Literature shows (Gardiner et al, 1996; Prasad, 1997) that a number of companies have responded to the challenges they face by modifying or re-engineering their NPI processes. However, one-off changes in the NPI process may not be enough due to the competitive pressures that continue to intensify. This has been recognised by some organisations who consequently have introduced ongoing improvement initiatives. The approaches adopted vary considerably in each company. The results also vary due to the fact that the focus of improvement initiatives has traditionally been within the manufacturing environment. Other contributors are the inherent culture of those involved in the NPI process and their perception that innovation cannot be controlled.

Performance measurement becomes more important in such an environment since the efficiency of the NPI process needs to be constantly evaluated and challenged. The research carried out here, therefore, is of great importance. The subsequent chapters will introduce a performance measurement system specifically developed for the characteristics and special requirements of the NPI process.

1.4.2 Performance measurement within NPI

One way to help disseminate the results of academic work to those in the field may be via industry awards and standards. There are several industry awards and standards that require evidence of procedure measurement and continuous improvement of all company processes including NPI. For example, in the USA the Malcolm Baldrige National Quality Award criteria cover translating customer requirements into design requirements, validating designs, and continuous improvement of the new product introduction process (Krehbiel, 1993; Evans, 1996). Companies entering for the European Quality Award (EQA) are required to demonstrate, amongst other things:

- How the organisation promotes the involvement of all its people in quality and continuous improvement;
- How process performance parameters, along with all relevant feedback, are used to review key processes and to set targets for improvement;
- How the organisation stimulates innovation and creativity in process improvement (Ghodobian and Woo, 1996)

Despite the above, the author has identified a lack of a performance measurement system to measure the effectiveness of the NPI process. A number of financial measures are currently in use produce information retrospectively. These financial measures are not in favour of the practitioners who complain that these measures do not provide them with any useful information for proactive action. The author has produced a number of indicators (chapter 8) as part of a performance measurement methodology to address this problem.

1.4.3 The need for research

In the present competitive climate, companies need to continuously monitor their NPI process and improve it. However, there seems to be a lack of a suitable measure to evaluate the performance of the process. There is relatively little in the literature on performance measures specifically catering for the unique needs of the NPI process. However, the lack of such measures is well expressed by both researchers and practitioners (Koliza et al, 2004).

Overall, there is pressure on companies to increase the performance of their NPI process. However, with no suitable measures in place it becomes very difficult to evaluate the current situation and improve upon it. As a result, some organisations have implemented a number of improvement initiatives on an ongoing basis with variable results. There has been little attempt to develop a performance measurement system within the context of NPI to assist in this task.

1.5 The research questions

There are a growing number of cases where improvements in speed and flexibility have been documented in manufacturing processes as a result of applying specific performance measures and continuous improvement practices (Bessant, 1992; Bessant and Caffyn, 1997; Locke and Jain, 1995; Mann and Kehoe, 1994; Maskel, 1991; Delbridge et al, 2002; Nachiappan et al, 2006). The question then arises, can similar benefits be achieved by extending the application of performance measurement and continuous improvement to the process of NPI. If the answer to the first question is positive then a method to do so will also be required. Despite the growing emphasis upon the application of performance measurement in the NPI the subject remains largely unpublished.

This thesis will target to address this gap in knowledge by investigating the scope for the application of a performance measurement system in the NPI process. It also aims to develop a framework for a method of evaluating the performance of NPI in organisations.

First the research must establish whether there is an opportunity to introduce a performance measurement system within the NPI process in theory. If a theoretical case can be established then the research needs to examine the extent to which it is possible and feasible to implement such a method in practice. In order to identify the range of opportunity for applying such a method to NPI processes the variations of the process context and the different company characteristics, such as type of organisation, industry, product etc. need also to be considered.

The nature of this investigation is both hypothesis generating as well as hypothesis testing. During the course of this work, the author developed a methodology to assist in the measurement of the performance of the NPI process. The methodology was further investigated with the use of research methods (survey, follow up interviews) and applied to a case study. In this dissertation the method is described in great detail to allow the reader to follow the case study for its application in the NPI context.

1.6 Overview of thesis structure

This thesis draws upon a number of sources to address the objectives and research questions (Q1 and Q2) under review. Figure 1.1 shows the sources utilised. Data gathered from the literature review, NPI industry practitioners, companies that participated in the survey and detailed case analysis and follow up telephone interviews carried out by the author assisted in the development of the performance model. The methods used are described and evaluated in detail in chapter 6.

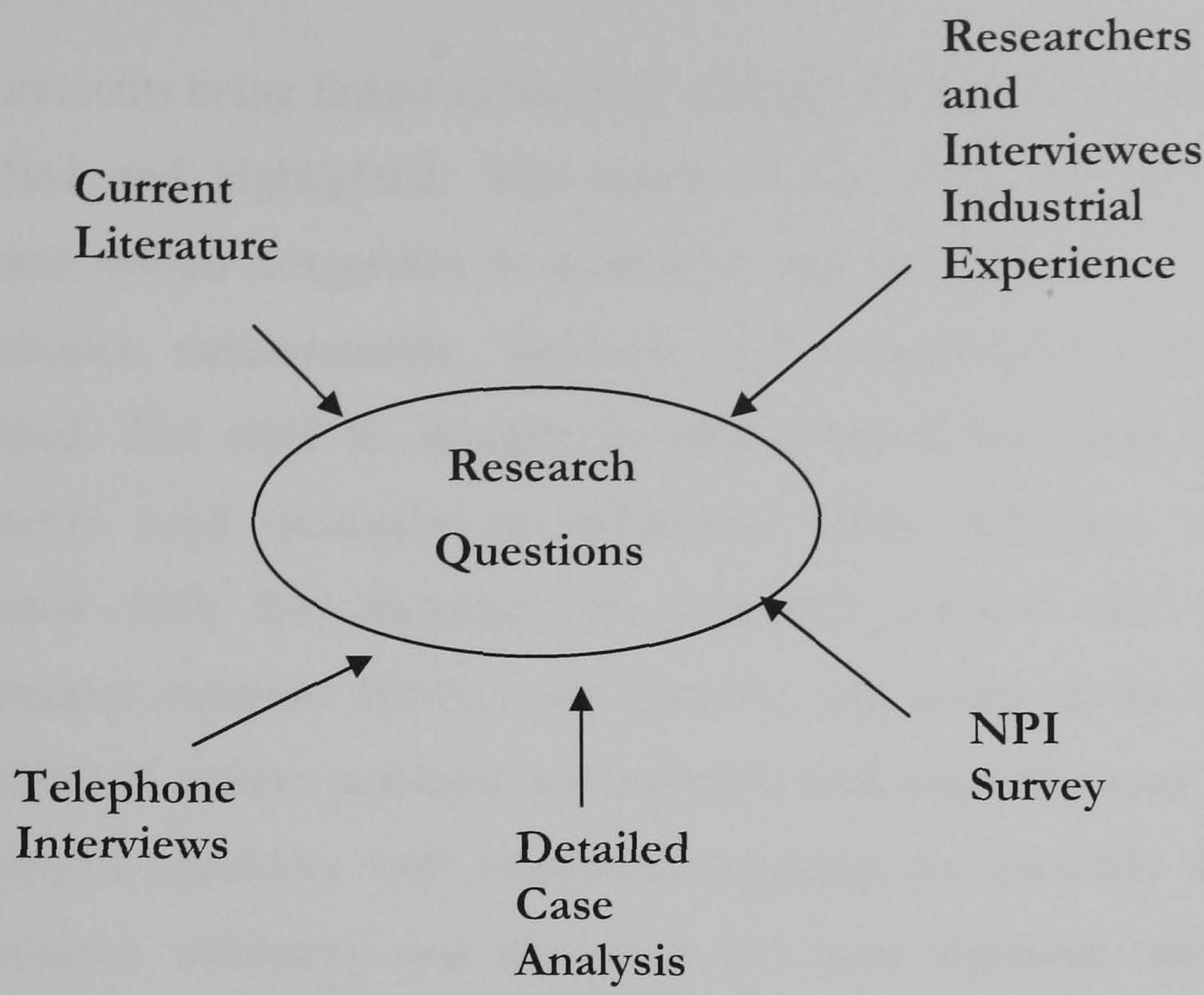

Figure 1.1. *Sources used to investigate research questions*

An outline of the thesis can be reviewed in figure 1.2.

Chapter 2 introduces the New Product Introduction (NPI) process and its importance to businesses. The most commonly used process sequences as well as the best practice NPI processes will be identified through the literature review and industry examples. The relationship between NPI and time-to-market will also be discussed in this section and its relevance and significance to business profitability will be reviewed. Specific company characteristics that influence the effect of time-to-market to business profitability will be identified from the results of a qualitative survey. This chapter concludes that company characteristics and attributes have an impact upon the development and adoption of a NPI model.

Chapter 3 presents the state of current published knowledge in the area of process performance measurement. The importance of performance measurements being linked to business strategy and business objectives is identified and highlighted. The extent of the usage of performance measures within companies is evaluated and the differences between performance measurements, measures and measurement systems are explained. The need to measure is also reviewed here and the most commonly used measures are identified. These measures are then compared with the elements of successful process and business performance measures found in the literature. The review of the literature also points to current problems and shortfalls with measures used. Finally, this chapter concludes with comments regarding the currently deployed performance indicators and the need for more dynamic and useful measures.

Chapter 4 argues the deployment of performance measurement within the NPI process. The contents of this chapter comprises a review of the contemporary literature on the subject and an outline of current practices based on results from a number of published surveys on multinational companies. The general trends of measures used for NPI will also be identified.

Chapter 5 summarises the findings and the conclusions drawn from the previous chapters as well as establishing and describing the lack and need of a performance measurement method for the NPI process identified within this research area.

Chapter 6 explains the underlying research philosophy of this thesis and the strategy followed. It describes and critically evaluates the main methods used to carry out the necessary research and investigation for this project.

Chapter 7 discusses and evaluates the research results. It draws on all the sources used in order to consider the application of performance measurements within the NPI process.

Chapter 8 describes the proposal of a new performance measurement system that will assist practitioners in forming and evaluating their NPI processes whilst providing them with an improvement plan for further development.

Chapter 9 outlines the steps taken to test and validate the proposed system and the application and suitability of performance measures within the NPI process.

Chapter 10 details the case study carried out in Company A (Appendix 1) that was willing to use the performance measurement method during the process of redesigning their NPI process. The activity provided a valuable experience for the author since the method was fully tested in a real organisation.

Chapter 11 summarises the conclusions identified on the basis of the arguments and evidence presented in this thesis. It also relates back to the original aims and objectives that are described in section 1.2 of this chapter.

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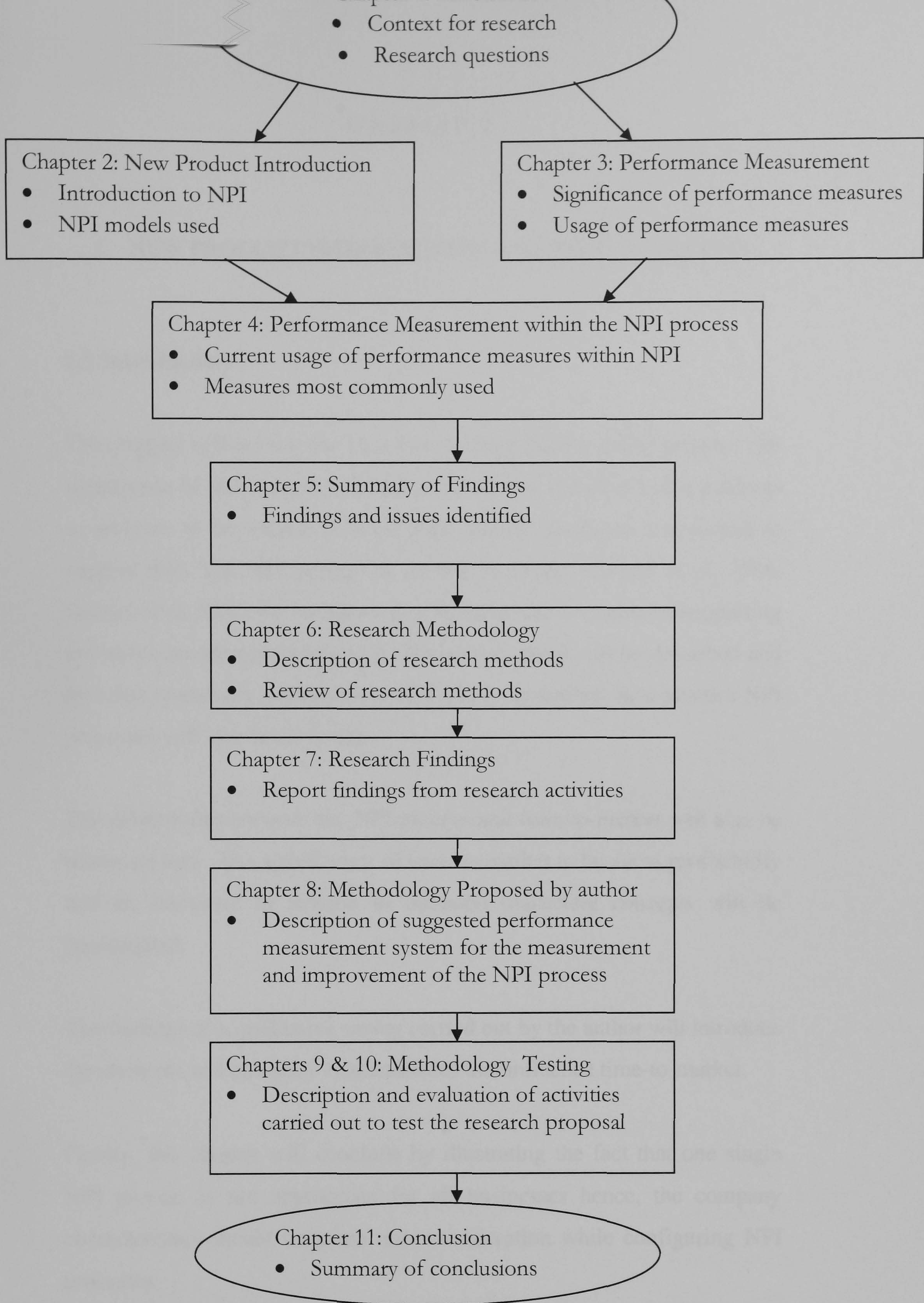

***Figure 1.2**. Outline of the Thesis*

Chapter 2

2. NEW PRODUCT INTRODUCTION AND TIME TO MARKET

2.1 Introduction

This chapter will review the New Product Introduction (NPI) process. The importance of this process to every business that introduces new products or services to the market is highlighted and the literature is reviewed to support this. The NPI process is quoted as being (Cooper et al, 1986; Dooley et al, 2002) the backbone of a business and a number of supporting processes are directly linked to it. The process itself will be described and the most commonly used styles of NPI will be identified. Best practice NPI processes will also be reviewed.

The relationship between the NPI process and time-to-market will also be discussed here. The significance of time-to-market to business profitability and its relevance in relation to common marketing concepts will be investigated.

The findings of a qualitative survey carried out by the author will introduce the elements and company characteristics that influence time-to-market.

Finally, this chapter will conclude by illustrating the fact that one single NPI process is not appropriate for all businesses hence, the company characteristics should be taken into consideration while configuring NPI processes.

2.1.1 Introduction to New Product Introduction

According to Shepherd et al (2000) and the author's experience, one of the most important processes in an organisation is the process by which new products or services are conceived, developed and produced. This process is commonly called the New Product Introduction (NPI) process. NPI encompasses the development of new products and/or modifications to existing ones, driven by market needs. It is vital for companies to realise the importance of this process and invest resources in developing the most efficient sequence of events that will make the product or service a success. This is essential due to the growing dependency on this process and recognition of its contribution towards company growth (Boag, 1989).

The author supports the view that an important aspect of an effective NPI process is that it should not be static, it should change and become more sophisticated to maintain market competitiveness. Interestingly, although the need for an established NPI process is evident, a number of firms still use no formal process for managing the introduction of new products to their markets (Owens, 2007).

The lack of such a process leads to lengthy and failure prone product launches, due to the disorganised product development and introduction routes followed. Many suppliers are under pressure from their customers to attain some sort of formal quality system certification along the lines of the ISO9000 series, or other national and international quality standards such as QS9000 and APQP (Advanced Product Quality Planning). This means that firms must not only be able to assure customers that established products will be produced in conformance to specifications, but also that a "right-first-time" mentality will influence the development and introduction of new products. "Right-first-time" is a key internal and external measure. In this case the internal benefits include faster and more reliable achievement of product development and subsequent production. Not getting things "right-first-time" means wasted effort, wasted resources, and wasted production time – all leading to excess costs. To the customer it means interruption and poor product delivery, poor product quality and ultimately higher prices.

Since the NPI process encompasses all the events from the initiation of a product idea to its production, it encompasses the working practices of several functions within an organisation (Trott, 1998). Based on the author's industrial experience, the preferred way of developing such a process is by forming a cross-functional task force that will include representatives from all disciplines involved. However, developing such a process is not an easy task due to the complexity (based on all the functions involved in the process and number of inputs and outputs that need to be controlled), time and effort required.

The successful introduction of a NPI process is a long term inter-departmental process. It will almost certainly be held back by a general lack of understanding and knowledge of best practice routines, the usual resistance to change, departmental interests, different functional priorities, cost justification issues, and various on-going projects.

To help overcome these opposing forces, the introduction of a formal NPI process needs the full support of top management throughout the implementation phase. Only top management will be able to resolve the interdepartmental issues that will arise from company-wide use of the NPI process. However, top management will not in most cases be able to get involved in all the details of the production and implementation of the best-fit NPI process.

2.1.2 The New Product Introduction Process

The importance of the NPI process has been recognised by those highly involved with this process, such as designers and programme/project managers, but also by manufacturing and marketing personnel. As the status of NPI activities within an organisation increase, the need to support this process with various tools and techniques is more frequently acknowledged (Jones, 1997). However, it is often very difficult to manage the conflict between the need for creativity and the need/desire for efficiency while defining a control process.

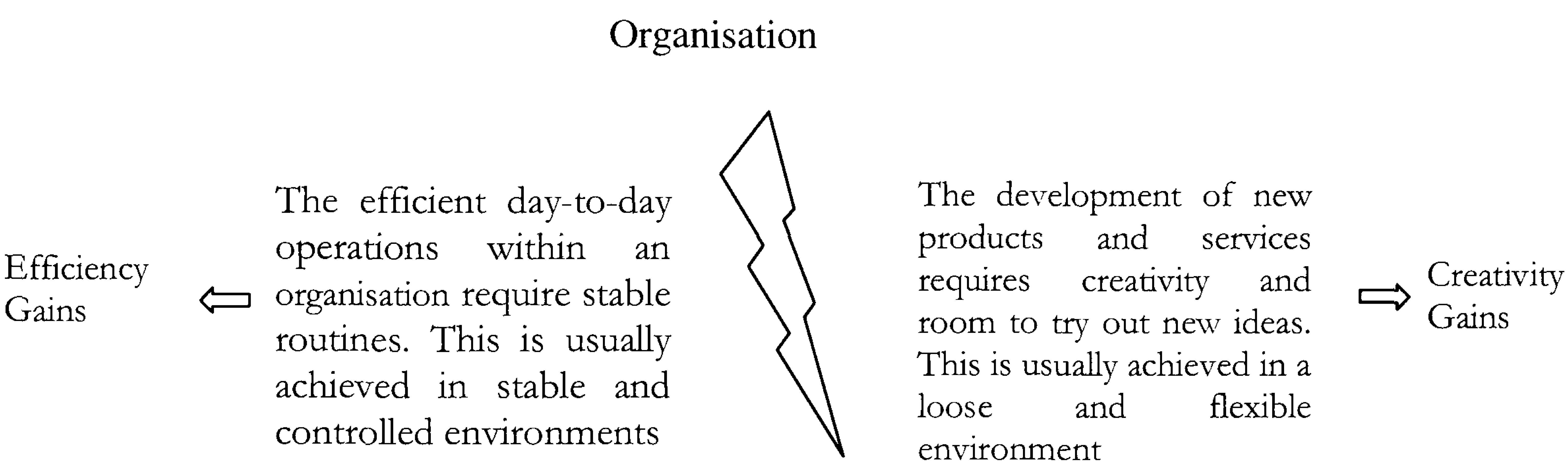

Figure 2.1. *The tension between creativity and efficiency*

The diagram above illustrates the need for control within the process. The introduction of controls leads to a stringent process that potentially increases the duration and length of specific activities. On the other hand, there is also the need for creativity in the process. This flexibility introduces risks that could lead to costly decisions during the development stages.

The author supports that there needs to be a structured process to guide those involved for all the crucial and mandatory steps to be fulfilled. However, this structured process has to be adaptable enough to cater for any variations that may arise due to the special product, customer and market characteristics. Such a process will ensure that all the tasks are carried out timely and efficiently while allowing room for creativity and a degree of flexibility. The need for speed and the need for control can co-exist in a flexible and dynamic NPI process.

There are a number of different NPI processes in the literature ranging from highly theoretical frameworks devised by academics to more practical methodologies adopted by companies. These processes attempt to balance between the need of efficiency and creativity. The British Standards Institute has also produced a standard for Design Management Systems (BS7000) that details the stages of an NPI process. However, there is no standard process that can suit all businesses. Different processes evolve for different industries, according to their particular needs. Some similarities do exist and most processes follow the same pattern. Jones (1997) has identified the different models of new product introduction as follows, based on the Saren (1984) taxonomy:

1. departmental stage models – sequential process that moves through various departments as it progresses from concept to finished product.
2. activity based models and concurrent engineering – the process is described in terms of the activities undertaken to develop the new product.

3. cross-functional models – this process emphasises on the use of project management and inter-disciplinary teams.
4. decision stage models – the process is broken down into a series of decisions. The decisions may be grouped according to the departments or activities they affect, or shown in the sequence in which they are addressed.
5. conversion process models – the process is represented as a system that transforms inputs, for example knowledge and customer needs, to outputs such as new products and services.
6. response models – the process comprises the stages involved when a company develops a response to an internal or external stimulus, which results in adopting or rejecting an innovation.
7. network models – the main emphasis in this process is on inter-organisational collaboration and the integration of internal and external networks.
8. holistic models – this process is based on a project team that works together throughout the duration of the process that takes the form of overlapping development phases.

The author has observed and Cooper, 1994 states that the most commonly used models are those with gates and audit points for go/no go decisions prior to committing resources and material for the next stage. The typical activities included in such a process include some or all of the following tasks listed by Cooper and Kleinschmidt (1986).

- Initial screening;
- Preliminary market assessment;
- Preliminary technical assessment;

- Detailed market study / market research;
- Business / financial analysis;
- Product development;
- In – house product testing;
- Customer tests of product;
- Test market / trial sell;
- Trial production;
- Pre-commercialisation business analysis;
- Production start up; and
- Market launch

Using a formal NPI process and not skipping steps in that process has been a differentiating factor between success and failure. However, even though the effectiveness of product introduction processes has been well proven, many companies still do not use a formal NPI process.

NPI processes continue to evolve and become more sophisticated. NPI changes continually on multiple fronts. The author supports that firms that fail to keep their NPI practices up to date will see a negative impact on market competitiveness. This is due to the increased levels of competition, rapidly changing market environments, higher rates of technical obsolescence and shorter product life cycles (Yelkur et al, 1996; Dacko, 2000).

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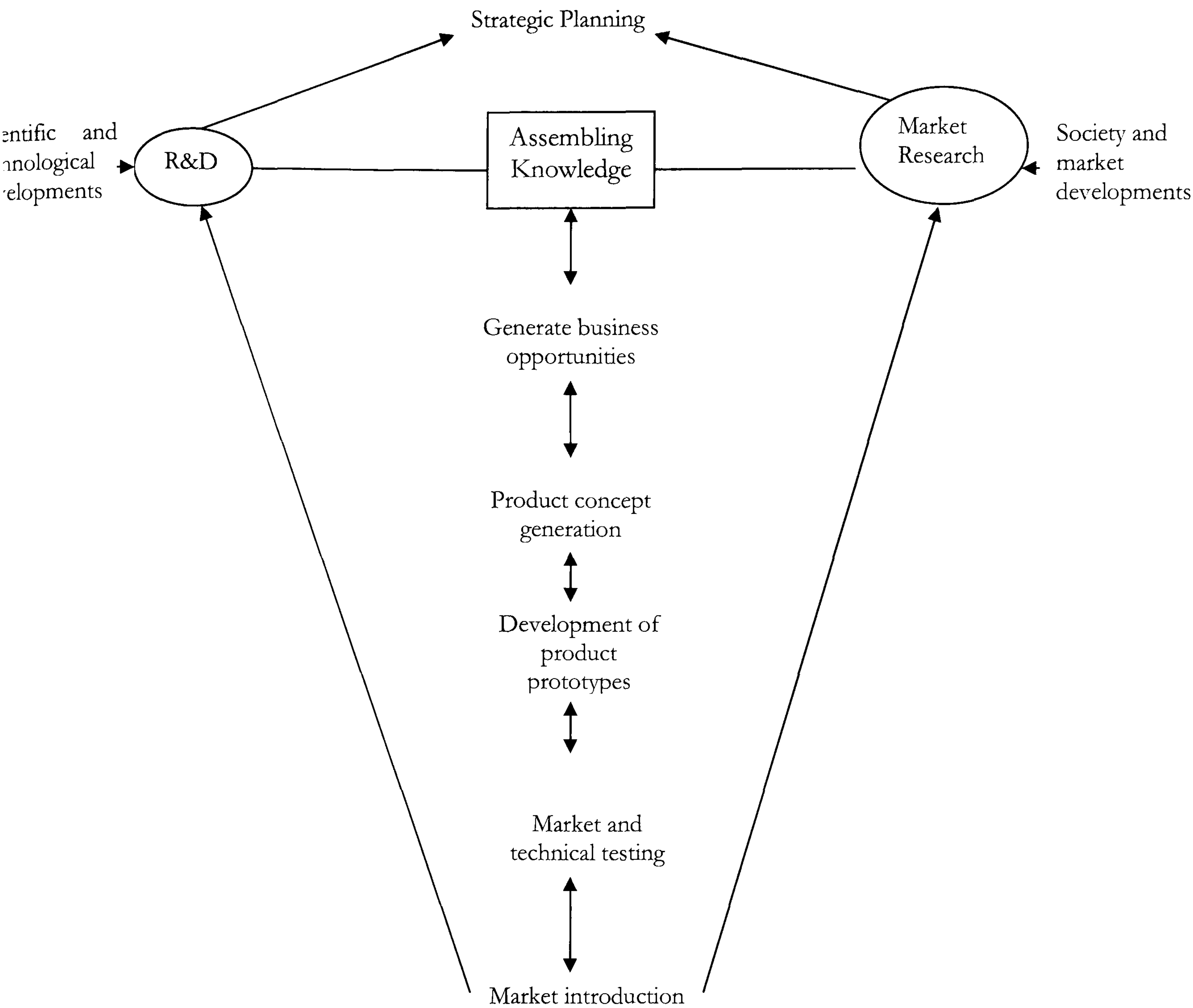

Figure 2.2. *A typical new product introduction system (Source: Trott, 1998)*

The NPI system illustrated above is based on the management framework of strategic, tactical and operational levels similar to the APQP (page 19) and Prince2 (PRojects IN Controlled Environments project management framework that focuses on organisational management and control) methodologies.

2.1.3 New Product Introduction Best Practices

Dooley K. J. et al (2002) observed that it is not uncommon, especially in large organisations, to see a variety of best practices being implemented with great success, but only within certain pockets of the organisation. The author has observed that a number of those companies that do follow a NPI process, are experimenting with numerous different best practices in order to improve the timelines and effectiveness of their process. Best practices associated with enhancing the human resources involved in NPI, and improving the fuzzy front end of NPI, appear to be getting little attention to date, despite a strong call for such attention in the management literature (Wang et al, 2002). Based on the author's industrial experience this seems to be the case for a number of companies. Best practices associated with the strategic implementation of NPI (project selection, goals, technological leadership, product strategy, and customer involvement) are on average more widely adopted than best practices associated with controlling the execution of NPI (process control, metrics, documentation, change control).

Researchers such as Griffin (1997) have devoted considerable effort to helping practitioners determine which tools, techniques, and methods really do offer a competitive edge. Starting around 30 years ago, research efforts have aimed at understanding NPI processes and identifying those that are deemed "best practices".

According to Wheelwright and Clark (1992), there is a widespread consensus that taking a process view is a good practice feature of the NPI process. In the early 1990s relatively few companies had adopted a process view and institutionalised it into a formal product introduction process (Cooper and Kleinschmidt, 1993). However, formal processes for managing NPI are becoming more common. The author supports that a formal NPI process will benefit all companies. By controlling the inputs and outputs for each stage of the process the quality, cost and timing of all the process activities can be monitored and controlled.

The author believes and literature supports (Hart, 1995) that crucial to the success and best practice NPI is linking the process used to business strategy. The product introduction process should fit with the company's objectives (Thomas, 1993). High performing companies have been found to strengthen their commercialisation capability by setting goals to focus the introduction efforts (Nevens et al, 1990). However, despite the growing recognition in the literature of the importance of the role of strategy in product introduction not all companies have a specific NPI strategy (Griffin, 1997; Garrido-Rubio, 2005).

2.2 Marketing Strategies and New Product Introduction

All businesses need to set objectives for their performance or for the performance of the products or services (Coehlo et al, 2003). These objectives are set to describe what the company, products or services are hoping to achieve. Setting objectives is a very important task. It focuses the company on specific aims over a period of time and can motivate staff to meet the objectives set.

A simple acronym used to set objectives is called SMART objectives (Beamish et.al. 2002). SMART stands for:

- **S**pecific – objectives should specify what they want to achieve;
- **M**easurable – there should be able to measure whether the objectives are being met or not;
- **A**chievable – objectives should be achievable and attainable;
- **R**ealistic – objectives should be achieved with the resources available; and
- **T**ime – objectives should be achieved within an agreed time-scale

There are a number of business objectives that an organisation can set. Some of those that the author has seen in different organisations are:

- market share objectives: objectives can be set to achieve a certain level of market share within a specified time. For example, obtain 3% market share of the mobile phone industry by the end of the year.

- to increase profit: this objective could be achieved by different ways, an example maybe to increase sales by 10% from the previous year.

- to sustain the business: fierce competition requires businesses to act against potential sales losses.

- to grow the business: the business may set an objective to grow by 15% year on year for the next five years.

- to increase brand awareness: companies may wish to invest in branding over a specified period of time.

However, there are many variables that operate within an organisation's environment that have a direct or indirect influence on their strategy and strategic goals. The author supports that a successful organisation is one that understands and can anticipate and take advantage of changes within their environment. An organisation's operating environment can be analysed by looking at:

- External forces – those factors that an organisation has no control over; and
- Internal forces – factors that an organisation has direct control over.

The business objectives set should focus on minimising the negative effect of these forces while maximising the positive ones. The external environment of an organisation can be analysed by conducting a PEST analysis (Middleton, 2003). This is an analysis of the Political, Economical, Social and Technological environment of an organisation.

The effect of the changing environment and customer needs and requirements can be detrimental for a number of businesses. As witnessed with the UK retail clothing group C&A, failure to react to the changing needs of its customers has resulted in C&A closing all their UK retail stores. Marks and Spencer's also seemed to face an uncertain future in the early 2000s. Research at the time showed that customers felt that the stores and clothes were outdated. M&S have now launched new lines and experimenting with new concept stores to retain existing and attract potential new customers.

However, an organisation cannot satisfy the needs and wants of all customers due to their extent, variety and complexity. To do so may result in a massive drain on company resources. Segmentation is simply the process of dividing a particular market into sections, which display similar characteristics or behaviour. There are a number of segmentation variables that allow an organisation to divide their market into homogenous groups. After the process of segmentation the next step is for the organisation to decide how it is going to target these particular groups.

There are three targeting options an organisation can adopt. These options can be found in marketing literature under different but very similar terms. Porter in the 1970s initially suggested the terms cost leadership, differentiation and niche strategy (explained in section 2.2.3), however other derivatives do exist.

Cost leadership or Undifferentiated marketing – sometimes referred to as mass marketing the firm may decide to aim its resources at the entire market with one particular product. Coca-Cola's original marketing strategy was based on this form. One product aimed at the mass market in the hope that a sufficient number of buyers would be attracted, although there are now changes in the product line to cater for growing dietary and caffeine free needs of consumers.

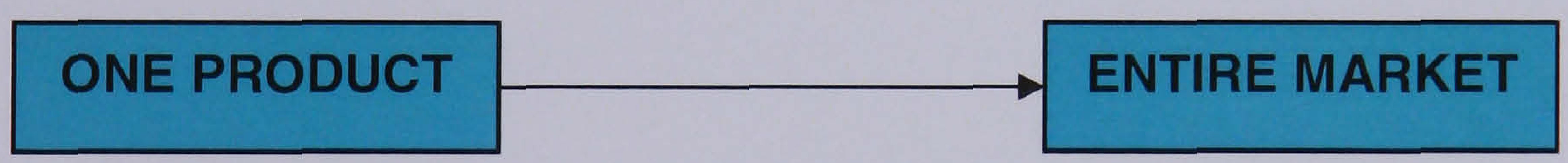

Figure 2.3*. Undifferentiated Marketing*

Differentiated marketing – a company decides to target several segments and develop distinct products/services with separate marketing mix strategies aimed at the specific groups. An example of this would be airline companies offering first, business or economy class tickets with separate marketing programmes to attract the different groups.

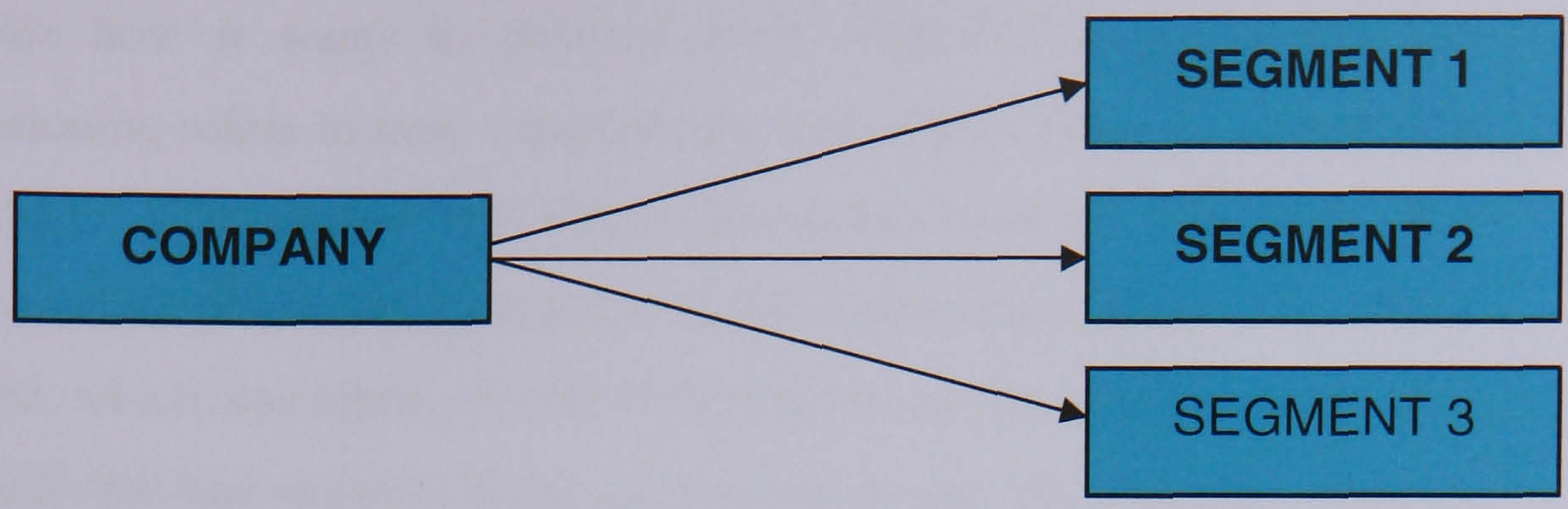

Figure 2.4. Differentiated Marketing

Niche or concentrated marketing – where the organisation concentrates its marketing effort on one particular segment. The company will develop a product that caters for the needs of that particular group. For example Rolls Royce cars aim its vehicles at the premium segment, in the same way as Harrods within the UK. Although Rolls Royce has a limited range and Harrods offers a vast range of products both companies target the high margin product segment.

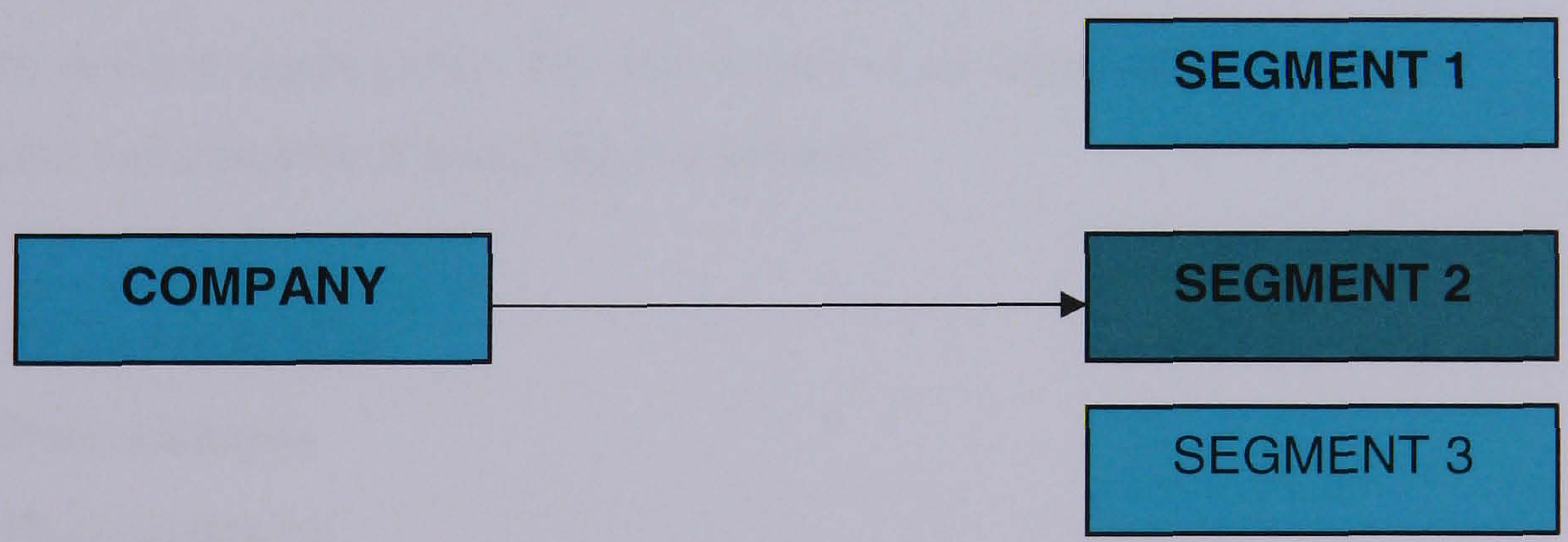

Figure 2.5. Concentrated Marketing

After an organisation has selected its target market the next step is to decide how it wants to position itself within that chosen segment. Positioning refers to how organisations want their customers to see their products. The current GM-Chevrolet brand, formerly Daewoo, have successfully positioned themselves as the family value model. The Skoda brand, which was taken over by Volkswagen, has been re-positioned as a vehicle that had negative brand associations to one that regularly wins car of the year awards. The positive comments from the industry and attributes of this brand are slowly changing the consumer perception of the Skoda brand.

Developing a positioning strategy depends on how competitors position themselves. Offering a benefit that is superior depends on the marketing mix strategy the organisation adopts. The pricing must reflect the benefit offered and the communication strategy must communicate this benefit.

The marketing mix principles, also known as the 4 Ps (Kumar, 2004 and Aaker et.al., 2003), are used by businesses as tools to assist them in pursuing their objectives. The marketing mix principles are controllable variables, which have to be carefully managed and must meet the needs of the defined target group. The mix is part of an organisation's planning process and consists of analysing the defined:

- Product strategies
- Price strategies
- Place strategies
- Promotion strategies

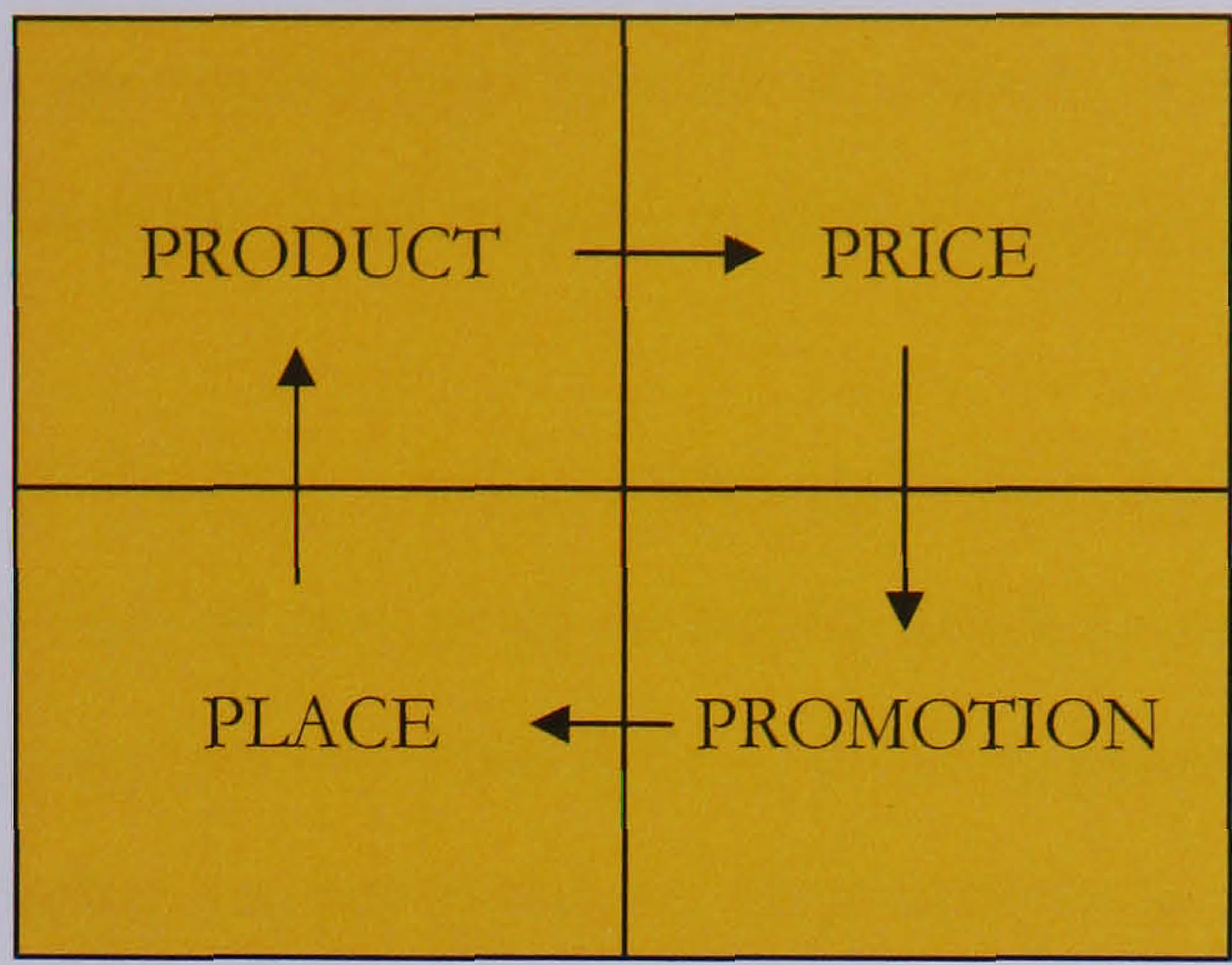

Figure 2.6. *The 4 Ps of Marketing Mix*

Product Strategies

When an organisation introduces a product into a market they must ask themselves a number of questions.

- Who is the product aimed at
- What benefit will they expect
- How is the product going to be positioned within the market
- What differential advantage will the product offer over competition

Kotler (2003), suggested that a product should be viewed in three levels:

Level 1: Core Product – what is the core benefit the product offers. Customers who purchase a camera are buying more than just a camera they are purchasing memories.

Level 2: Actual Product – all cameras capture memories. The aim is to ensure that the potential customer purchases the company's product. The strategy at this level involves an organisation's branding, added features, time of entrance to the market and benefits to ensure that the company's product offers a differential advantage from their competitors.

Level 3: Augmented Product – what additional non-tangible benefits can be offered. Competition at this level is based around after sales service, warranties, delivery and so on. John Lewis retail department store offers free five-year guarantee on purchases of their television sets. This gives their customers the additional benefit of "peace of mind" over the next five years should their purchase develop a fault.

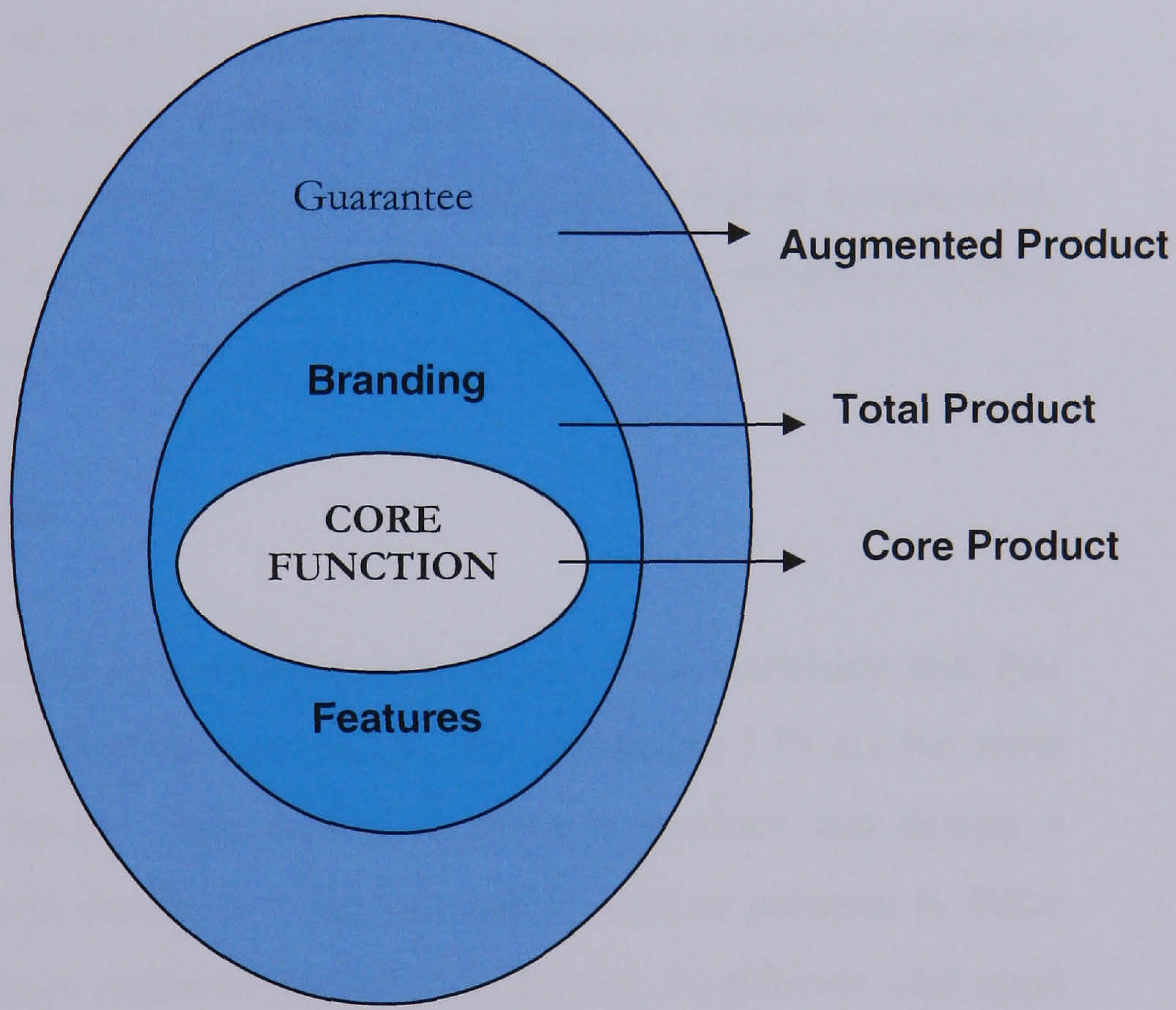

Figure 2.7. *The three Product Levels*

When placing a product within a market many factors and decisions have to be taken into consideration. These include:

- Product design – will the design be the selling point for the organisation as it can be seen with iPod, the VW Beetle or the Dyson vacuum cleaner.
- Product quality – quality has to be consistent with other elements of the marketing mix. A premium based pricing strategy has to reflect the quality a product offers.
- Product features – what features will be added to increase the benefit offered to the target market, as well as the use of discriminatory pricing policies for offering these additional benefits.
- Branding – one of the most important decisions a marketing manager can make is about branding. The value of brands in today's environment is phenomenal. Brands have the power of instant sales, they convey a message of confidence, quality and reliability to their target market.

Pricing Strategies

Pricing is one of the most important elements of the marketing mix that generates turnover for the organisation. The remaining 3 Ps are the costs that may vary for the organisation. It costs to produce and design a product, it costs to distribute a product and it costs to promote it. Price must support these elements of the mix. Pricing is difficult and must reflect the supply and demand relationship. Pricing a product too high or too low could mean a loss of sales for the organisation. Pricing should take into account the following factors:

- Fixed and variable costs
- Competition
- Company objectives
- Proposed positioning strategies
- Target group and willingness to pay

An organisation can adopt a number of pricing strategies. The pricing strategies are based on what objectives the company has set itself to achieve.

Penetration pricing: where the organisation sets a low price to increase sales and market share.

Skimming pricing: the organisation sets an initial high price and then slowly lowers the price, as competitors enter the market, to make the product available to a wider market. The objective is to skim profits off the market layer by layer. The opportunity of using this method to its full potential increases when a company's time to market is shorter than that of its competitors.

According to Kotler (2003), the practice of 'price skimming' involves charging a relatively high price for a short time where a new, innovative, or much-improved product is launched onto a market. The objective with skimming is to "skim" off customers who are willing to pay more to have the product sooner; prices are lowered later when demand from the "early adopters" falls and other competitors that enter the market. The main objective of employing a price-skimming strategy is to benefit from high short-term profits due to the newness of the product as McGrawth (2000) identifies.

Examples of companies that are using this type of pricing strategy are those like Sony with the Playstation introduction and those organisations with digital technology products.

	PRICE: Low	PRICE: High
SELLING EFFORT: Low	Necessity Goods	Skim Strategy
SELLING EFFORT: High	Penetration Strategy	Luxury Goods

Figure 2.8. *Pricing Strategies*

Competition pricing: setting a price in comparison with competitors.

Product Line pricing: pricing different products within the same product range at different price points. An example would be a manufacturer offering different DVD recorders with different features at different prices. The greater the features and the benefit obtained the greater the consumer will pay. This form of price discrimination assists the company in maximising turnover and profits.

Group pricing: the organisation groups products together as a set at a reduced price.

Psychological pricing: the company will consider the psychology of price and the positioning of price within the market place. The seller will therefore charge 99p instead of £1 or $199 instead of $200.

Premium pricing: the price set is high to reflect the exclusivity of the range. An example of products using this strategy would be Harrods, first class airliners, Porsche, Rolls Royce etc.

Optional pricing: the organisation sells optional extras along with the product to maximise its turnover. This strategy is used commonly within the car industry.

As products move through the four stages of the product life cycle different promotional strategies should be employed at these stages to ensure the healthy success and life of the product. The timing of the products into the market also influences the selection of which is the most appropriate pricing strategy to follow in order to maximise turnover.

Place strategies

Refers to how an organisation will distribute the product or service they are offering to the end user. The organisation must distribute the product to the user at the right place at the right time. Efficient and effective distribution is important if the organisation is to meet its overall marketing objectives. If an organisation underestimates demand and customers cannot purchase products because of it then the profitability will be affected.

Promotion Strategies

A successful product or service means nothing unless the benefit of such a service can be communicated clearly to the target market. An organisations promotional strategy can consist of advertising, public relations, sales promotion, personal selling or direct mail.

2.2.1 Product Life Cycle

The product life cycle concept suggests that a product passes through four stages of evolution: introduction, growth, maturity and decline. As a product evolves and passes through these four stages profit is affected, and different strategies have to be employed to ensure that the product is a success within its market.

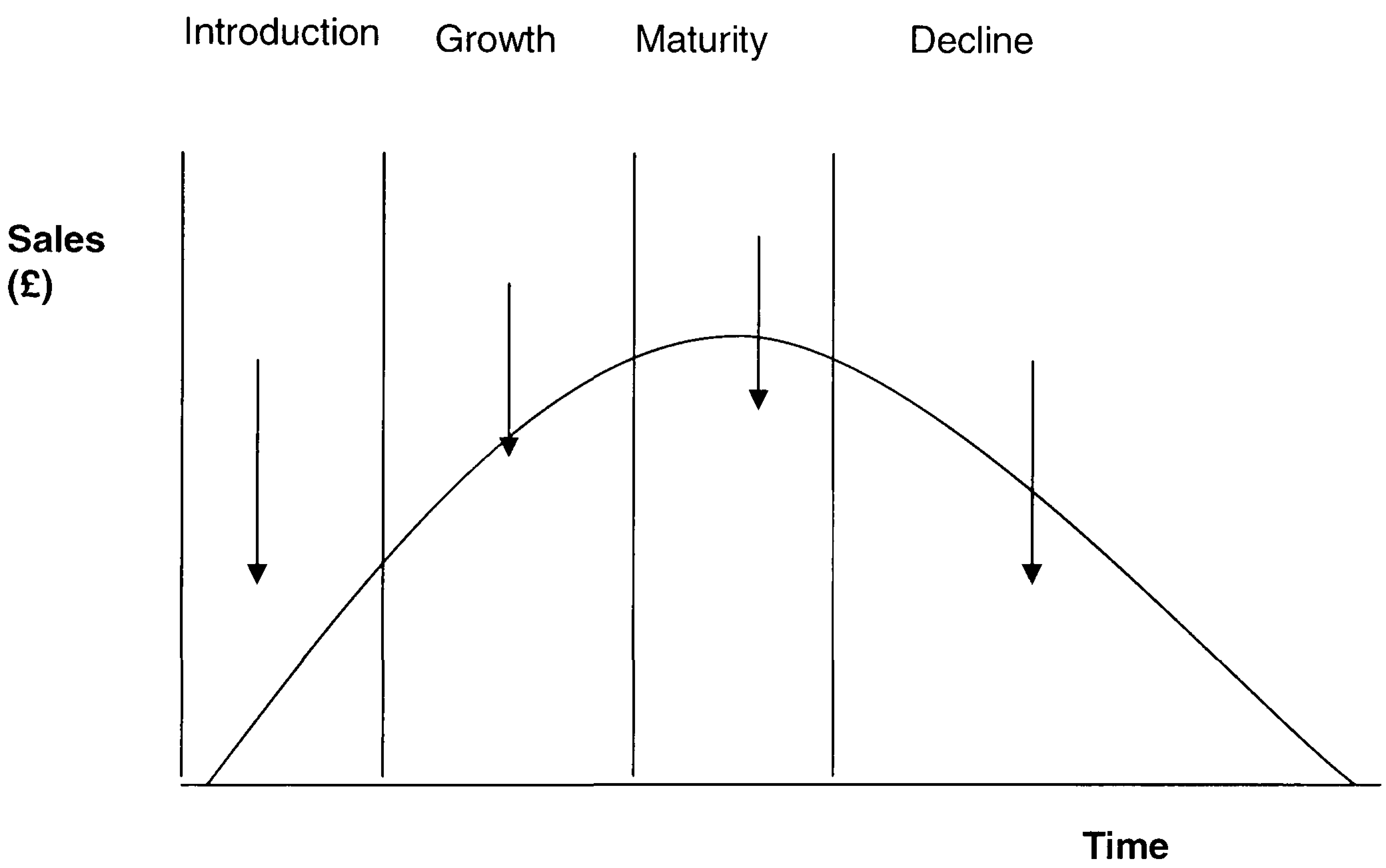

Figure 2.9. *The Product Life Cycle (PLC)*

Introduction: at this stage a substantial amount of time will be spent to create awareness amongst the target market. This is the reason why during this period profits are negative or very low.

Growth: after consumer acceptance of the benefits the product offers, the organisation will realise a period of rapid sales growth.

Maturity: rapid sales growth does not last throughout the rest of the product life cycle. Sales slow down as the product sales reach their peak.

Decline: sales and profits start to decline, the organisation may try to change their pricing strategy to stimulate growth, however, the product will either have to be reviewed, modified, or replaced within the market.

Igor Ansoff in 1957 developed a tool that can be utilised to assist marketing decisions throughout the product life cycle. According to Ansoff's model (Volberda et.al. 1998) there are five strategic business options.

1. Market Penetration: this involves increasing sales of an existing product and penetrating the market further by either promoting the product heavily or reducing prices to increase sales.

2. Product development: the organisation develops new products aimed within their existing market, in the hope that they will gain more customers and thus market share. An example of this is Sony launching the Playstation 2 product to replace their existing model.

3. Market development: the organisation adopts a strategy of selling existing products to new markets. This can be done either by a better understanding of segmentation or by selling the product to new markets overseas.

4. Diversification: moving away from the current market and core activities to a new market with new products.

5. Consolidation: the organisation adopts a strategy of withdrawing from particular markets, scaling back on operations and concentrating on its existing products in existing markets.

		PRODUCT	
		Current	New
MARKET	Current	Market Penetration	Product Development
	New	Market Development	Diversification

Figure 2.10. *Ansoff's Matrix*

Another tool that can be utilised is the Boston Consulting Group (BCG) matrix (Botten, 2004). This product portfolio matrix classifies product lines into four categories. The BCG model suggests that organisations should have a healthy balance of products within their range. The BCG classified these products as following:

Dogs: these are products that have low market shares and low market growth rates. The option of many companies is to phase these products out, however some organisations select the strategy of re-inventing and injecting new life into the same products, Heinz have followed this path successfully.

Question Mark/Problem Child: these are products with low market share that operate in high market growth rates. The company needs to allocate a lot of resources in these products in the hope that they will eventually increase market share and generate cash returns in the future.

Star: stars have high market shares that operate in growing markets. The product at this stage should be generating positive returns for the company.

Cash Cow: cash cows are products at the mature stage of the lifecycle, they generate high amounts of cash for the company, but growth rate is slowing. There are chances that the product may slip into decline. Appropriate marketing mix strategies should be employed to prevent this.

BCG MATRIX

MARKET GROWTH		
High	Star (growth stage of PLC)	Question Mark (introduction stage of PCL)
Low	Cash Cow (maturity stage of PLC)	Dogs (decline of PLC)
	High	Low

***Figure 2.11**. The BCG Matrix*

2.2.3 Generic Strategies

During the 1970s Michael Porter suggested that for an organisation to obtain a sustainable competitive advantage they should follow either one of the three generic strategies detailed below.

Strategy 1: Cost Leadership

This strategy involves the organisation aiming to be the lowest cost producer within their industry. The company aims to drive cost down through all the elements of the production of the product from sourcing, to labour costs. The cost leader usually aims at a broad market, so sufficient sales can cover costs. Low cost producers include easyJet airline, Ryan air, Asda and Walmart. Another group of companies may aim to drive costs down however, they will not pass on these cost savings to their customers aiming for increased profits, clearly due to their brand demanding premium rates.

Strategy 2: Differentiation

Having a competitive advantage that allows the company and its product range to stand out is crucial for their success. With a differentiation strategy the company aims to focus its efforts on particular segments and charge for the added differentiated value. New concepts that allow for differentiation can be patented, however, patents have a variable life span and organisations always face the danger that the idea that provides them with a competitive advantage may be copied in one form or another.

Strategy 3: Niche strategies

Companies focus their efforts on one particular segment and become well known for providing products/services within that segment. They form a competitive advantage from this niche market and either succeed by being a low cost producer or differentiator within that particular segment. Examples of this strategy include Rolls Royce, Morgan and Bentley.

The danger a number of organisations face is that they try to follow all three strategies resulting in no clear business objectives. No clear brand strategy could lead to increased running costs and a fall in sales and market share.

2.2.4 Conclusion

From the literature reviewed above there is a link between the product life cycle and the marketing strategies to be adopted by organisations. In certain companies the choice might be clear dependent on the product, the customer and the market that they are in. However, it is most likely that this choice will not be so straightforward. In a number of organisations an amalgamation of strategies and methods might be more appropriate.

The NPI process is a process that spans throughout the product life cycle therefore it is influenced by the marketing strategy selected. This may also complicate and direct the process through a certain route to satisfy the criteria of the preferred strategy. Therefore, the author believes that a common universal NPI process would not be able to cater for all of the possible variances and specific business objectives.

The author also suggests that each organisation needs to review their individual characteristics and objectives and decide upon a process that will suit their needs. Generic guidelines may be followed however, not all of them may be appropriate for the optimum NPI process.

2.3 Time to Market

2.3.1 Introduction to Time – to – Market

Being fast enough to be first into the market, with the right product, is worth more to the success of most businesses than probably any other single management or manufacturing action (Markides et al, 2005). Models developed by PA Consulting show that the benefit of being first to market can largely counteract an overspend in development costs; for example, a 50% overspend on development in order to be first into the market resulted in just 15% reduction in the net profit over the product's lifetime. In contrast, being late in development and therefore second to enter the market could reduce profits by 50 – 90%, and delaying a launch to introduce an extra feature would reduce product lifecycle profitability substantially.

Time-to-market is the time it takes to bring an offering from the conception of the mind to the hand of the customer. In business process terms, time to market is the elapsed time between product or service definition (concept) and its availability (market introduction). Many companies attempt to reduce the time to market of their products and services because this can increase competitive advantage. Being faster to market enables a greater market share and price realisation by utilising strategies such as skimming pricing. For example, it has been estimated (Stalk et al, 1990) that in the electronics industry, introducing a product nine to twelve months late can reduce its potential lifetime revenues by 50%. A long development process exposes the project to the risk of change in the market and environment. Particularly when product lifecycles are short, product modifications, and replacements need to be managed more effectively if market share and profits are not to be lost.

A study by Hutchin (2000), of the major players in the communication market and design and manufacturing companies in the retail electronics market showed the effect of late deliveries of their projects. The researchers claim that the delays resulted in heavy penalties both financial and organisational, features were dropped, again resulting in penalties with substantial budget overrun and considerable stress amongst the project teams.

Today's markets demand much more flexibility than in the past. Customers are less willing to wait for their product. This is observed in most organisations if not all, across various different markets. An example is given by Andrews et al (2000) where supermarkets demand very short delivery times and will often only firm up orders a few days before delivery. Many automotive companies that follow the Just In Time concept demand similar flexibility.

Time to market, along with quality, cost and delivery, is an important measure of the performance of product introduction projects, together with productivity and quality. Typical measures include frequency of new product introduction; number of products started and completed (actual versus planned); and the percentage of sales resulting from new products.

For most organisations (Johnson R. et al, 2000) there is constant external pressure from the market to reduce supplier response time and price as well as internal pressure to reduce lead-times and costs. There are a number of successful techniques both technological and managerial that have been successfully utilised to respond to these pressures. Some of these tactics approach the time to launch new and/or revised products while others tackle the production lead-time of the overall supply chain. Either approach may also have a positive impact on cost.

The author suggests that delays in the NPI process potentially lead to extended time-to-market and eventually longer lead times. Time-to-market is an important measure of the performance of an organisation, together with productivity and quality. Especially, when product lifecycles are short. Product modifications and replacements need to be managed more efficiently if market share and profits are not to be lost.

By striving to reduce the time-to-market the development and product introduction costs can also be reduced. According to Stalk et.al. (1990), the total development costs can be lowered since the early exchange of information and resolution of conflict results in the need for fewer engineering changes. Less inventory can result from shorter cycle times, followed by lower overhead costs, such as reduced breakdown costs, delays, and number of working hours. Shorter time to market also means that companies get more opportunity to improve the sales performance of their products and services.

In addition, if a company is late in getting its products and services to market compared to its competitors, the effect will be felt on its market share, its revenue and therefore its overall profitability (Wheelwright et al, 1992). If the development process takes longer than expected (or even worse, longer than competitors) two effects are likely to result. The first is that the cost of development will increase. Having to use additional development resources such as designers usually increases the costs of development. Perhaps more seriously, the late introduction of the product or service will delay the sales revenue (and possibly reduce the total revenue substantially if competitors have already entered the market with their own products or services). Lost opportunity costs are also realised due to the delay. The net effect is likely to be a considerable reduction in sales and reduced profitability, an outcome that could considerably extend the time before the next new product or service is launched.

Jones (1997), has summarised the benefits of a short time-to-market as follows:

- By being early to market with a well-designed product, companies can obtain a greater return on their investment.

- Rapid product development gives the potential to achieve an increased market share and an extended sales life, as well as freeing resources for more projects.
- To achieve this, appropriate organisational structure and cultures have to be adopted to enable time for concurrent engineering to take place.
- Development teams need to have the necessary skills and experience to use the relevant technologies both creatively and efficiently.
- Only by recognising all of these areas can manufacturers significantly improve the design and performance of their products, enabling them to compete successfully in both domestic and international markets and reap the rewards that are available.

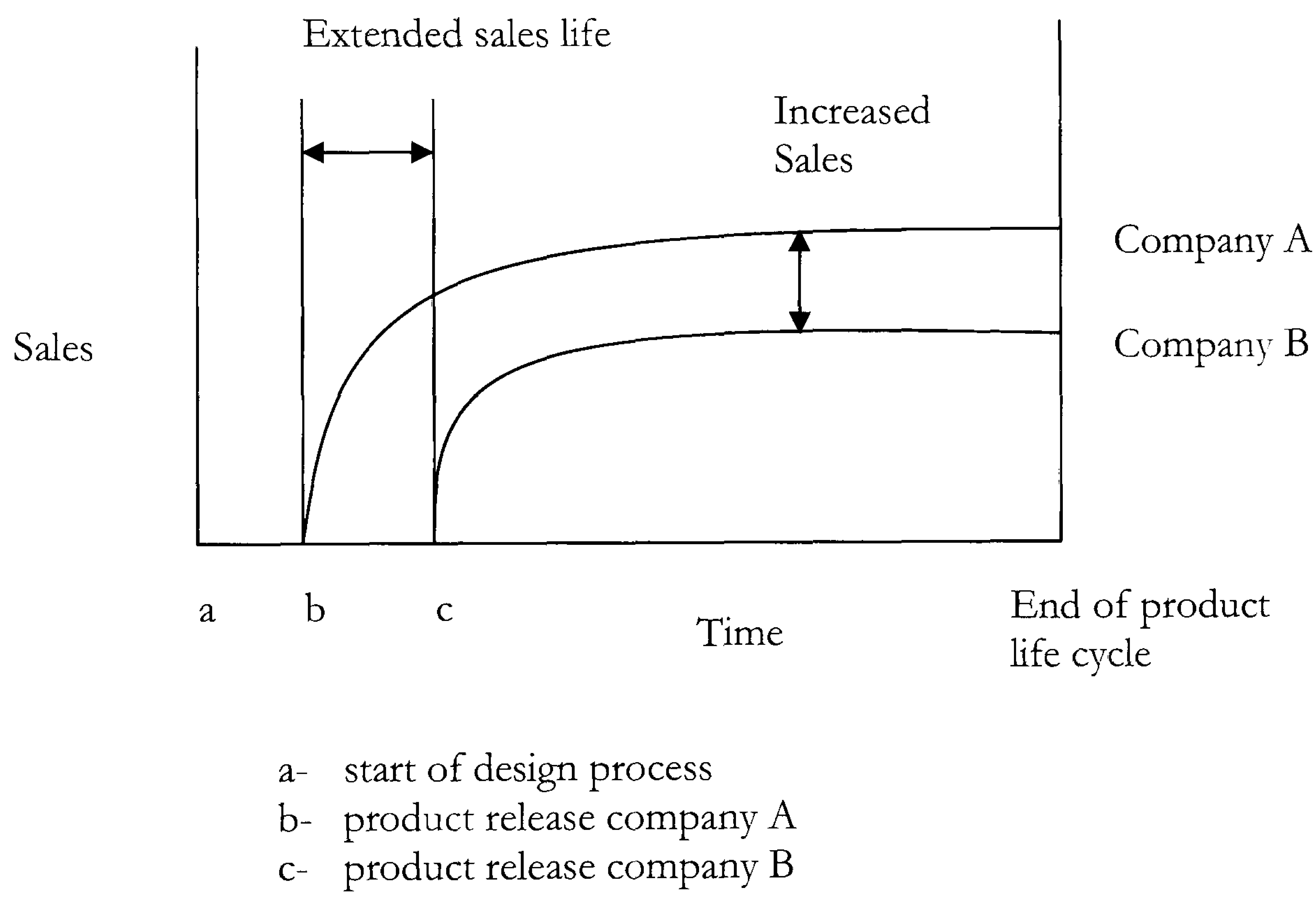

Figure 2.12. *Benefits of reaching the marketplace faster than your competitors (Huthwaite, 1996)*

The author supports that in today's world, the primary criterion is time, so businesses that want to gain strategic advantage need to be focused on reducing time-to-market.

2.3.2 Factors that influence Time-to-Market

There are several attributes that contribute to extending the time-to-market (TTM) and are realised by companies irrespective of their industry and target market.

The author as part of the investigation in identifying factors that influence time-to-market carried out a survey to see whether literature references correspond to what organisations are experiencing. Two companies where involved in the process Company A and Company B (Appendix 1) due to the access of personnel and information that the author had within these companies. The details of these companies can be reviewed in pages 103 – 104. Based on this research, a summary of the most common reasons as well as their potential root cause can be seen in the following table as well as the fishbone diagram. Interviewees included Engineering Directors, Project Managers, Electronic Engineers, Mechanical Engineers and Software Engineers from Company A and B with a record of multiple development and new product projects.

Table 2.1. Immediate and Root causes of extended TTM

IMMEDIATE CAUSE	*ROOT CAUSE*
Marketing quotes unrealistic lead times, to satisfy customer requirements, leads to high customer expectations, fuzzy front end	• Poor knowledge of what the business can achieve • Lack of an established method to communicate what the business can achieve • Lack of tools to hold the above information
Documentation is often late, incorrect, or of no use in the format that it arrives	• No formal procedures to specify what documents and when they are required • Process too complicated to follow • Culture that documents are not necessary • Lack of knowledge of the end user needs • Disorganisation
Long development process	• Complex product • No design standards • Culture that the design is an innovative process and cannot be structured within timescales • No formal process
Many engineering changes to incorporate	• No stable design • Complex product • Obsolescence • Customer requirements change • Customer requirements not well

	defined and understood • Production issues • No Design for Manufacture
Poorly defined and practised NPI process	• Outdated methods • Wastage throughout the process • Lack of continuity • Lack of automation of processes • Not knowing what comes next • Not knowing the internal customers' needs • Disorganisation
Poor project management	• Lack of training • Lack of knowledge of project management techniques • Culture that is difficult to stick to timescales throughout the product development process
Poor production planning and control	• Inadequate Sales Operations Planning process • Lack of communication between sales, engineering, and manufacturing

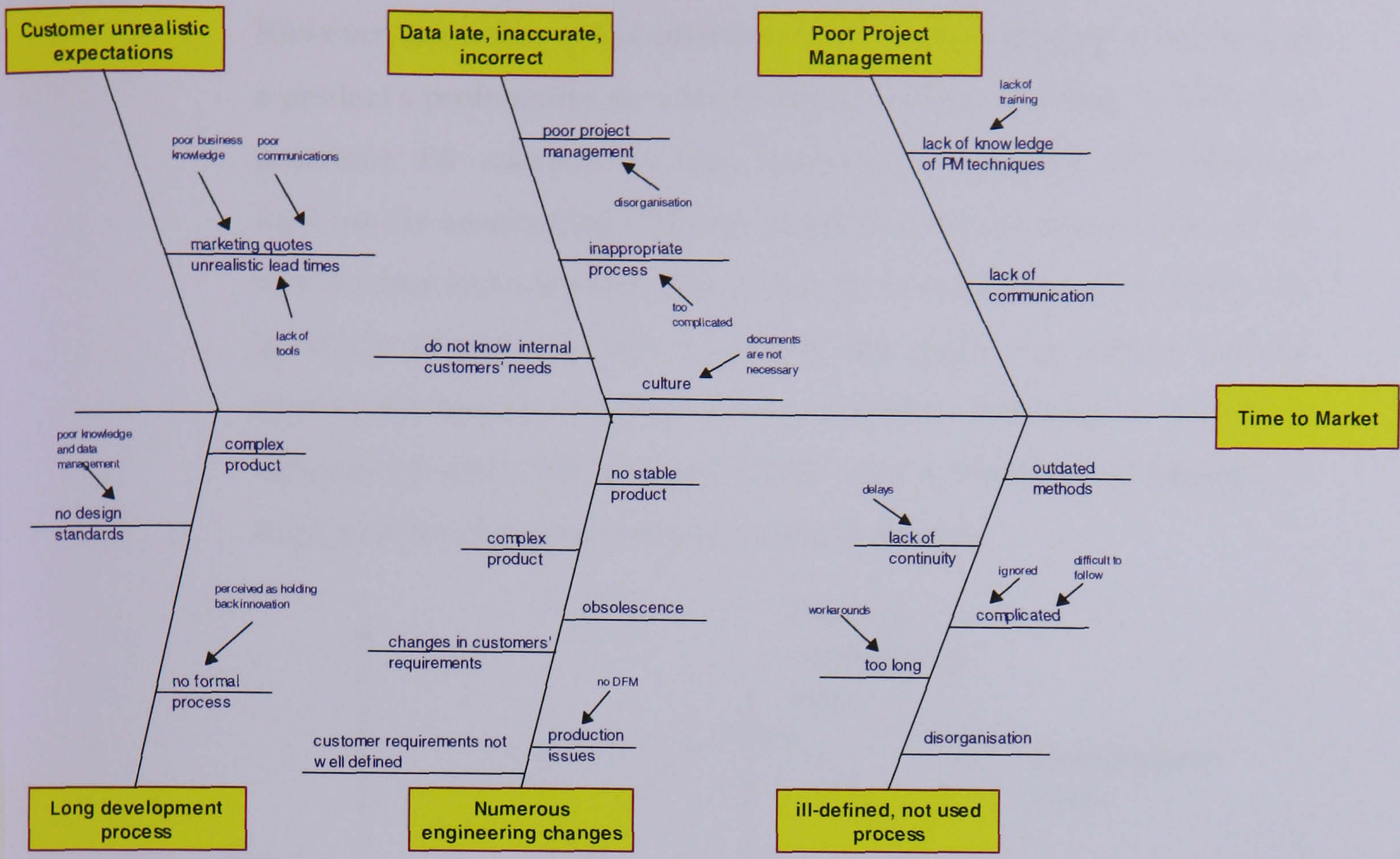

Figure 2.13. *Cause and Effect (Fishbone) Diagram*

(Source: Qualitative Research carried out by the author in November 2002)

A number of factors have been suggested by Slack (2004) which can significantly reduce time to market for a product or service, including the following:

- Simultaneous development of the various stages in the overall process;
- An early resolution of design conflict and uncertainty;
- An organisational structure that reflects the development project.

However, according to Commandeur (1995), although time to market and a product's profitability are closely linked, simply speeding up NPI is no guarantee for success. In fact, haphazardly adopting the numerous methods for accelerating NPI may jeopardise the potential success of the new product and company. This is due the introduction of calculated risk in favour of time as well as actions that might not cohere with the appropriate business strategy. Those companies that seek to reduce the duration of their NPI process should take a hierarchical approach to implementing the various improvement techniques.

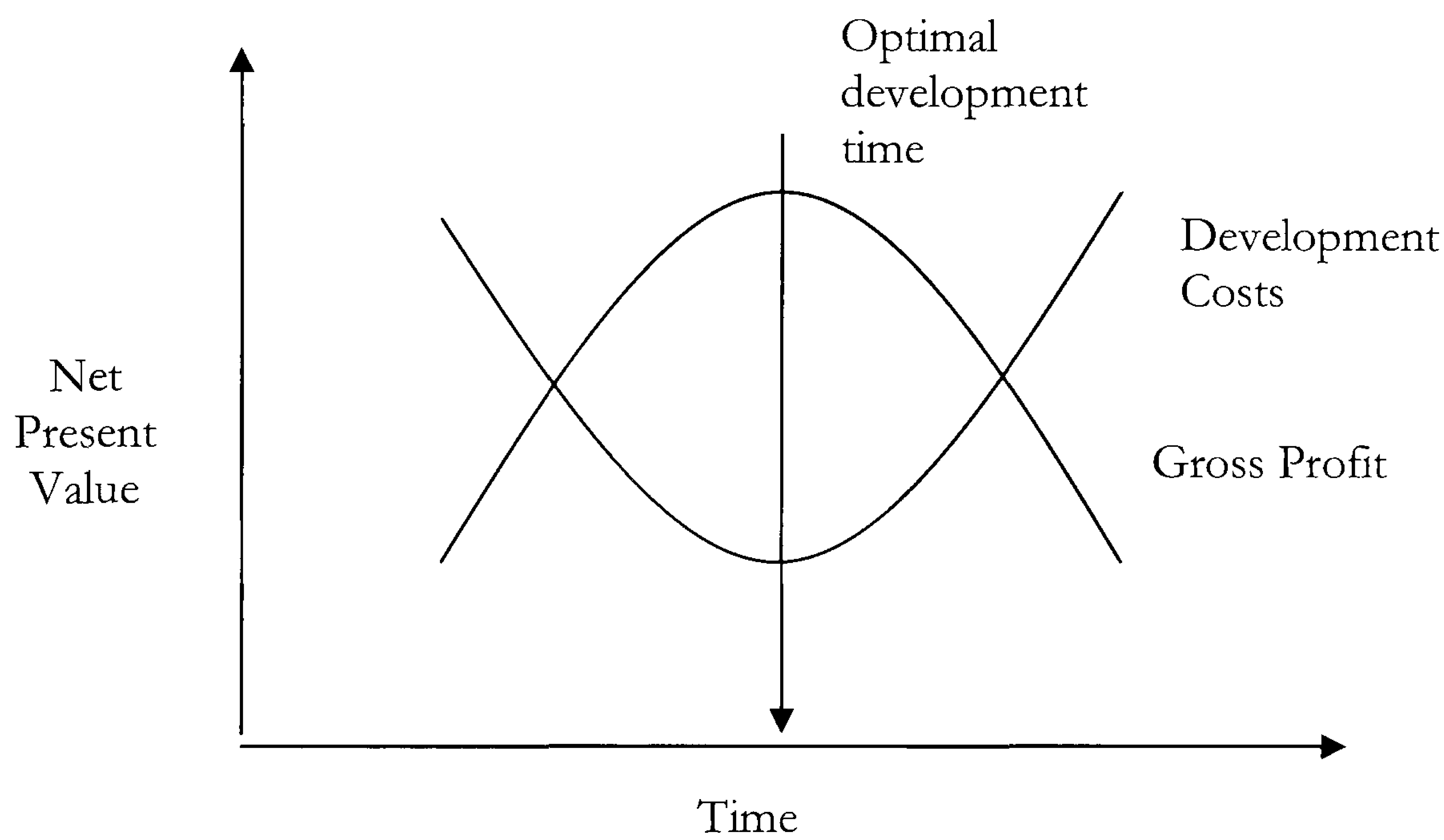

Figure 2.14. *Optimal Development Time (Source: Murman 1994)*

Studies carried out by Murnann (1994) have indicated the existence of an optimum development time, as illustrated at Figure 2.14. Shortening development time to below the minimum of the U-shaped curve means increasing costs due to additional parallel processing that causes more co-ordination expenditures and additional expenses for overtime. Conversely, lengthening development time raises the cost due to losing know-how and motivation.

2.4 Discussion

New products are central to the growth and prosperity of the modern corporation. In order to provide value and win customers, companies need to quickly and accurately identify changing customer needs and wants. They need to develop more sophisticated products to satisfy these needs, provide higher levels of customer support and service while also utilising the power of information technology in providing greater functionality, performance and reliability (Cooper and Kleinschimdt, 1991). Consequently, new product introduction has become a central mechanism through which a company's strategy can be put into practice.

The NPI process involves many activities that can be grouped into a number of phases or stages. The extent to which these activities are followed varies, as they are organised, managed and executed in numerous ways. The models and frameworks observed are constantly evolving incorporating features that will increase the efficiency and effectiveness of NPI. Companies are under increasing pressure to improve their performance, especially when it comes to introduction costs and cycle time.

There is a need to find an effective balance between the time required to develop a new product and the ability to have it ready when the market is ready. Firms have tried to improve their rates of success in the global marketplace by accelerating NPI execution and speeding time to market (Topfer, 1995). The subsequent benefits to be accrued (as illustrated at Figure 2.15) tend to attract managerial attention, since justification for proceeding with a project tends to focus heavily on financial measures such as Return on Investment (ROI). The specific benefits demonstrated include extended sales life, extra revenue, lower costs and higher (premium) profits, increased market share and customer loyalty, a technological edge and a good image for technology, delivery and quality (Pavar et al., 1994).

According to Shepherd et al (2000), time to market improvements can also allow a company to gain success in time sensitive markets, where predictability of supply and time to market can become a competitive advantage.

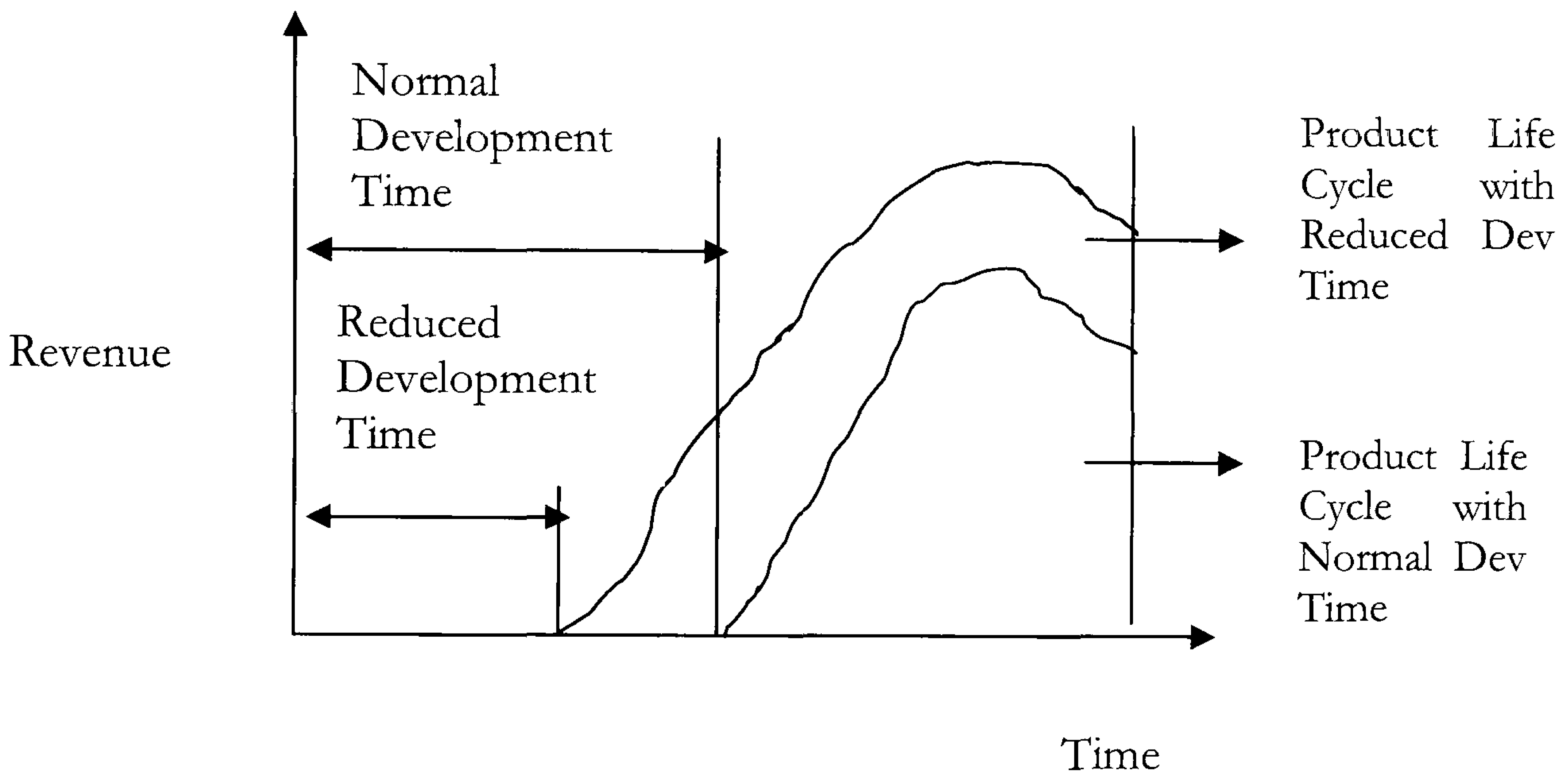

Figure 2.15. *The financial impact of shorter time to market (Source: Pitiglio et al 1992)*

Time to market is the relationship between time, a business and its marketplace. The essence of rapid time-to-market is responding quickly to change and customer demands. The winners in today's competitive marketplace are those companies that can bring innovative high value products and services to the customer ahead of their competition (Murray, 1998).

However, this might not be possible or suitable for all companies in all industries. As Markides and Geroski (2005) point out, in certain primarily demand-driven markets first-mover advantages do exist, an example being a company such as eBay that captured a certain percentage of the market and had all the substantial first-mover advantages over everyone else. However, in the creation of radical new markets, i.e. markets that are created primarily through new technology or the combination of existing technology to create something entirely new there are advantages to be gained for fast second movers. Examples of very successful fast second movers are: in the VCR market JVC took a large market share from Sony, the pioneering model of Netscape was overtaken in the market by Microsoft, diet cola was launched in 1952 by a company called Kirsch, Pepsi and Coca Cola only entered the market in the 1960s.

It is evident that each different organisation needs to review their particular characteristics, market trends and peculiarities prior to deciding which marketing strategy they should follow. The selected strategy will then be translated into the company objectives that all functions should strive to achieve.

2.5 Conclusions

The author reviewed the different company NPI processes and argues that the same process does not fit in every company. Hence, the number of different NPI processes in the literature. A single process cannot be expected to satisfy different companies' unique characteristics and targets.

Based on the literature reviewed in this chapter the author concludes that organisations, before identifying or re-configuring their NPI process, should look first at their customers. They should identify what values, linked to their products and services, their customers appreciate and strive to excel against their customers' expectations through the steps of their chosen NPI process. Secondly, the products and services need to be reviewed. Their attributes and characteristics need to be taken into consideration. The process needs to make sure that the final product or service is designed, developed and produced using the most appropriate methods. Thirdly, the market needs to be accessed. The NPI process needs to be aligned to the trends and peculiarities of the target market to maximise market share and reduce competition. Finally, the process needs to be flexible and workable.

The author supports that a balance should also be identified between control and time to market. A process that is designed to rigorously follow specific steps introduces high control and minimises risk of failure and rework. This type of process also requires low maintenance and management. One shortfall of such a process could be that it becomes time consuming which will increase the processing time while minimising the benefits of early market entry. Parallel processing could be introduced to reduce time to market. However, this could increase the risk that can lead to costly mistakes.

The author suggests that a well-defined and optimised NPI process that has considered all of the above will be an efficient and effective process. This process will assist the company in achieving the optimised time-to-market according to its market and product requirements. Assuming the suitable control mechanisms are in place, this process should increase market share and company profit.

3. MEASUREMENT OF PROCESS PERFORMANCE

3.1 Introduction

Business critical activities and collaboration between different functions and departments need to be identified and defined as company business processes. These processes can be informal or formally documented with flow charts used as a visual representation of the process steps. The efficiency and effectiveness of these processes affect the overall business performance, which is linked to business profitability. It is therefore paramount for businesses to measure the performance of their processes. Performance indicators are most commonly used to obtain the information required.

Organisations set off by defining their business strategy usually at a very high level that gives focus to its managerial workforce. The strategic plans that usually cover a number of years are then translated to business objectives that are more specific with hard targets to be achieved. Finally, the business objectives are taken a step further to operational objectives that process owners and practitioners need to achieve. By this cascade of targets and objectives the actions of the operators can be directly linked to and affect the business strategy. Businesses usually have a set of key performance indicators to assess the effectiveness of their processes and operations that are directly linked to corporate strategy and business objectives.

In this chapter the process performance measurement field will be evaluated. The literature will be reviewed in order to establish the extent of performance measurement in businesses. The differences between performance measurement, performance measure and performance measurement systems are explained to provide clarity when using these terms. The need to measure is reviewed and the most commonly used measures are identified.

The current status of performance measurements and performance measurement systems is also reviewed and the elements and attributes of successful process and business performance measures are itemised. These attributes will be used later against the method developed by the author (chapter 8). The review of the literature will also pinpoint current problems and identified shortfalls of measures used. Finally, the chapter concludes with comments regarding the currently deployed performance indicators and trends for more dynamic and useful measures.

3.2 Introduction to Process Performance Measurement

Lord Kelvin (1824 – 1907) said that: "*When you can measure what you are speaking about, and express it in numbers, you know something about it...[otherwise] your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in thought advanced to the stage of science*".

In business, performance measurement is an essential element of effective planning and control. The level of performance a business attains is a function of the efficiency and effectiveness of the actions (processes) it undertakes. In most organisations the measurement of the efficiency of their processes proves to be easier than the measurement of their effectiveness. The term effectiveness is used here, according to the Oxford Dictionary of English (2005), as "*producing the result that is wanted or intended; producing a successful result*". The same source describes efficiency as "*the quality of doing something well with no waste of time or money*".

In a cycle of continuous improvement, measurement plays an important role in identifying opportunities and comparing performance against internal and external standards. Measures are used in *process control*, e.g. control charts, and in *performance improvement*, e.g. impact and effect of improvement teams. In their respective applications they should give information about how well processes and people are doing and motivate them to perform better in the future.

Performance and measure are two words often found in the literature alongside each other. However, there are differences in the meaning of the following most commonly used phrases: performance measurement, performance measure and performance measurement system. According to Slack (2004):

- *Performance measurement* can be defined as the process of quantifying the efficiency and effectiveness of action.
- A *performance measure* can be defined as a metric used to quantify the efficiency and/or effectiveness of an action.
- A *performance measurement system* can be defined as the set of metrics used to quantify both the efficiency and effectiveness of actions.

3.2.1 The need for measurement

Business processes are the foundation to all activities that are carried out in all organisations. The effectiveness of these processes can only be identified by a measure that reviews and monitors the outputs, final or interim, of this process. Oakland (1996) stated the elements that the defined and agreed measures should cover.

- To ensure customer requirements *have* been met.
- To be able to set sensible *objectives* and comply with them.
- To provide *visibility* and a 'score-board' for people to *monitor* their own performance levels.
- To highlight *problems* and determine which areas require *priority attention.*
- To give an indication of the *costs of poor processes.*
- To justify the *use of resources.*
- To provide *feedback* for driving the improvement effort.

Measures and indicators must refer to the numerical information quantifying input, output and performance dimensions of processes, products, services and the overall business. According to Esposito et.al. (2000), there are several reasons why measurement of performance is necessary and why there should be an organised approach to it:

- Performance measures indicate the degree of accomplishment of objectives
- Performance measures are needed to monitor the continuous improvement process, which is required for the business to become and remain competitive

- Measurement of individual, team and business unit performance is required for periodic performance review by management.

In general, process performance measures should mainly be utilised to portray the impact of process improvements in business performance, on sustaining current performance and perhaps on reducing any decline in performance.

3.2.2 Measures of performance

In the business of process improvement, process understanding, definition, measurement, and management are inextricably linked. In order to assess and evaluate performance accurately, appropriate measurement must be designed, developed and maintained with the partnership and consultation of the people who *own* the processes concerned. However, although the process owners are the most knowledgeable individuals to carry out this task, conflict of interest might result in measures that do not correctly represent the performance of the process in question.

Practitioners find it necessary to measure effectiveness, efficiency, quality, impact, and productivity. In these areas there are many types of measurement, including direct output or input figures, the cost of poor quality, economic data, comments and complaints from customers, information from customer or employee surveys, etc. generally continuous variable measures (such as time) or discrete attribute measures (such as absentees).

According to Oakland (1996), there is no generic list in existence of what should be measured but, once it has been decided what measures are appropriate, they may be converted into indicators. These include ratios, scales, rankings, financial and time-based indicators. Whichever measures and indicators are used by the process owners, they must reflect the time performance of the process in customer/supplier terms and emphasise continuous improvement.

All performance measurement systems consist of a number of individual performance measures. There are various ways in which these performance measures can be categorised, ranging form Kaplan and Norton's (1996) balanced scorecard through to framework of results and determinants. Performance measures need to be positioned in a strategic context, as they influence what people do. Measurement may be the "process of quantification", but its affect is to stimulate action. As Mintzberg et al (2003) have pointed out, it is only through consistency of action that strategies are realised.

A number of performance measures widely used in current systems are involved in measuring the Quality, Time, Cost, and Flexibility of different business processes. Globerson (1985), suggests that the following guidelines can be used to select a preferred set of performance criteria:

- Performance criteria must be chosen from the company's objectives.
- Performance criteria must make possible the comparison of organisations, which are in the same business.
- The purpose of each performance criterion must be clear.
- Data collection and methods of calculating the performance criterion must be clearly defined.
- Ratio-based performance criteria are preferred to absolute number.
- Performance criteria should be under control of the evaluated organisational unit.

- Performance criteria should be selected through discussions with the people involved (customers, employees, managers).
- Objective performance criteria are preferable to subjective ones.

Similarly, according to Neely et.al. (1995), there are seven principles of performance measurement system design:

1. The measures should be directly related to the firm's manufacturing strategy.
2. Non-financial measures should be adopted.
3. It should be recognised that measures vary between locations - one measure is not suitable for all departments or sites.
4. It should be acknowledged that measures change as circumstances do.
5. The measures should be simple and easy to use.
6. The measures should provide fast feedback.
7. The measures should be designed so that they stimulate continuous improvement rather than simply monitor.

The author supports that traditional measures of financial performance encourage managers to adopt a short-term perspective. In the current strategic trend of continuous improvement cycles the author based on her industrial experience has identified that measurement plays an important role in:

- Identifying opportunities for improvement (quality costing).
- Comparing performance against internal standards (process control and improvement).
- Comparing performance against external standards (benchmarking)

3.3 Current status of performance measures and measurement systems

Today's businesses utilise performance measures and performance measurement systems for a number of reasons. Most of the time their use forms a requirement described by the quality or management standards that the company would like to obtain and maintain such as ISO 14001:1996, ISO9001:2000 or BS standards. In a number of cases they form part of the performance matrix as key performance indicators. Different industry forums (i.e. Aerospace and Automotive Industry Forums) have identified and introduced a number of key performance indicators that claim to provide executive and meaningful business information. In other instances, performance measures are utilised by line managers to control, monitor and review improvement progress of their localised processes.

However, there are some performance measurement systems that frustrate practitioners and prohibit improvement efforts. Various problems include systems that (Bititci et al, 2000):

- produce irrelevant or misleading information.
- track performance in single, isolated dimensions.
- generate financial measures too late, e.g. quarterly, for mid-course or remedial action.
- do not take account of the customer perspective, both internal and external.
- distort management's understanding of how effective the organisation has been in implementing its strategy.
- provide behaviour that *undermines* the achievement of the strategic objectives.

Typical harmful summary measures of local performance are purchase price, machine or plant efficiencies, direct labour costs, and ratios of direct to indirect labour (Oakland and Sohal, 1996). These are incompatible with improvement measures such as process and throughput times, delivery performance, inventory reductions, and increases in flexibility, which are first and foremost non-financial. Financial summaries provide valuable information, however, they should not be used as a means for process control. Effective decision-making requires direct physical measures for operational feedback and improvement.

One example of a commonly used measure with the shortcomings identified above is return on investment (ROI). ROI is typically used initially to justify an investment and then at the end of a project to compare the end-of-project ROI with the original estimate. ROI can be computed after profits have been totalled for a given period. Therefore, it was designed as a single period, long term measure. However, by reviewing the measures most commonly featuring on company's performance boards, ROI is increasingly being used as a short-term measure. The author supports that this measure is not a predictive measure, it describes very well what may take place or took place throughout the life of a project. The author also argues that it offers no data that would assist in identifying what is likely to happen when used during the lifecycle.

The author has observed that the practitioners involved in the NPI process are not in most cases financially aware. Financial indicators, although suitable for top level analysis, do not measure the performance of the process. Additionally, the financial indicators used in many businesses appear to have remained static while the environment in which organisations operate has changed dramatically.

The author has also observed throughout her industrial experience that another common problem with the indicators that are used is the fact that obtaining data to feed the measurements can be a lengthy task. Taking measurements is often seen as a burden rather than part of the process. In determining the appropriate intervals at which to measure, there is a need to consider how fast the input conditions change. Some factors influencing the frequency of measurement are identified by Esposito et al. (2000) as follows:

- Purpose: the metric can indicate a trend or a control output.
- Cost: the amount of time/money needed for measuring.
- Rate of Change: this factor influences the maximum time between measurements.
- Degree of Control: how soon an unfavourable change can be corrected.
- Consequence: this factor is connected to the amount of acceptable risk.
- Baseline: is there existing data on how the metric performs over time.

Considering all of the points discussed above, suitable measures should be able to be defined for those processes that have an impact upon the overall business performance.

3.4 Discussion

The author supports that the sustainability of an organisation is directly linked to the continual improvement of business performance. As Flavio et al. (2003) have identified, many organisations have found a way to improve performance through the establishment of management systems. To increase benefits of the system, it is necessary also to develop and implement a well-structured performance evaluation process to assist both the business and its interested parties achieve agreed objectives, in a sustainable way.

Based on the research carried out on the subject the author recognised that a management system in itself is not enough to improve performance. Within the management systems, it is also necessary to develop and implement a well-structured performance evaluation methodology if the business and interested parties objectives are to be met in a sustainable way. The management systems standards state that organisations have to measure and monitor key characteristics of their activities to assess their performance.

There appears to be a growing recognition that the measures of performance that companies have traditionally used are inappropriate for manufacturing businesses (Gomez et al, 2006), because they:

- encourage short-termism, for example the delay of capital investment.
- lack strategic focus and do not provide data on quality, responsiveness and flexibility.
- encourage local optimisation, for example manufacturing inventory to keep people and machines busy.
- encourage managers to minimise the variances from standard rather than seek to improve continually.
- fail to provide information on what their customers want and what their competitors are doing.

The author identified that accounting measures are mainly applied for performance evaluation but these financial-ratio-based models have significant problems in considering non-financial qualitative factors, which are very important in performance evaluation. In addition, these models use financial statements of part years and try to predict a system's future or current performance. A thorough performance analysis should also include qualitative and quantitative non-financial information, which may not be available in financial statements but are needed to better judge a firm's performance (Yadakul, 2002).

In addition, the measures used have not been linked to the processes where the value-adding activities take place. Improvement measures need to provide feedback to employees in all areas of business operations.
The final issue, and one that has not yet been addressed, is that of predictive performance measurement. Managers use measures both to monitor part performance and stimulate future action. Increasingly, however, people are beginning to look for "predictive" measures. Measures such as statistical process control show that a process is going out of control are useful because corrective action can be taken before too much damage has been done. A key item on performance measurement research agenda must therefore be the identification, and/or development, of "predictive performance measures".

Hartel et.al. (2000) and others (Mackenzie, 2000; Krishman and Ulrich, 2001) have identified and the author supports that measuring process performance is essential to process management. Process management does not only involve the identification and implementation of a process. The process effectiveness is also an element that needs to be considered. The author believes that the key to success in process management is knowing the efficiency of a process in order to prevent issues rather than solving them after they occur. According to Harrington (1991), Davenport (1993), Hammer and Champy (1993) and Johansson et.al. (1996), process management is an inherent part of the business process reengineering technique, and according to Pzydek (1999) and Harry and Schroeder

(2000), Six Sigma quality systems focus on measuring process performance as well as end results.

3.5 Conclusion

Traditionally, performance measures and indicators have been derived from cost accounting information, often based on outdated and arbitrary principles. These provide little motivation to support attempts to introduce process improvement and, in some cases, actually inhibit continuous improvement because they are unable to map process performance.

Kaplan and Norton (1996) and Vavio (1999) are amongst a number of reviewers that promote the use of non-financial measures in strategic justification. It has been argued that financial measures should be complemented by non-financial indicators and organisations are being advised to establish multidimensional measurement systems, thus altering traditional approaches to measurement (Johnston and Kaplan, 1996; Bennett and Forrester, 1993).

However, reviewing the Weston et.al. (2000) findings, despite analysing a number of cases advocating non-financial measures, evidence of their use in the UK is limited. A survey of the use of performance measures by executives and board members in 77 UK companies found that financial measures, such as financial return and working capital, were used most often.

For either financial or non-financial measures, the same good practice principles apply. The critical elements of a good performance measurement and management effort look like any other list associated with business improvement.

- Leadership and commitment.
- Full employee involvement.
- Good planning.
- Sound implementation strategy.
- Measurement and evaluation.
- Control and improvement.
- Achieving and maintaining standards of excellence.

The author supports that the management of performance measures can be greatly assisted by the use of Deming's (1987) cycle of continuous improvement - PLAN DO CHECK ACT. This cycle clearly requires measurement, and yet it is a useful design aid for the measurement itself:

PLAN: establish performance objectives and standards
DO: measure actual performance
CHECK: compare actual performance with the objectives and standards - determine the gap
ACT: take the necessary actions to close the gap and make the necessary improvements

Business performance measures and systems need to evolve from being overall historic indicators of performance to dynamic meaningful data that can be utilised to result in process and thus business improvement. A combination of financial and non-financial measures will compliment each other while offering a holistic view of the effectiveness of the processes they measure. Finally, the selected indicators should be relevant to the business process they scrutinise, with the data they require being well defined and easily obtainable. With such measures featuring in the business management system, management and practitioners will be provided with information that they can relate to and act upon quickly in order to prevent performance losses.

The importance of performance measurement is generally recognised in the literature (Driva et al, 2000) and by the industry. However, the adequacy of metrics applicable to different aspects of the organisation does not appear to have been addressed. The measures used to evaluate the New Product Introduction process are analysed next and their suitability and value to practitioners is assessed.

4. PERFORMANCE MEASUREMENT OF THE NPI PROCESS

4.1 Introduction

The profitability of an organisation is directly linked to the continual improvement of business performance (Tangen, 2002). According to Najmi et al, 2005, and the author agrees, many organisations have found ways to improve their performance through performance measurement systems. The importance of such systems as well as individual performance measures is generally recognised in the literature and the industry. Traditionally (Draman et al, 2002) and in the author's experience, performance measures and indicators have been derived from cost accounting information, often based upon outdated and arbitrary principles. These provide little motivation to support attempts to introduce process improvement and, in some cases, actually inhibit continuous improvement because they are unable to map process performance. Additionally, the author believes and Driva et al (2001) supports that the adequacy of metrics applicable to different aspects and processes within an organisation, such as the New Product Introduction process, does not appear to have been addressed.

Work on performance measurement to date has led to monitoring performance and stimulating future action. Increasingly, however, managers are beginning to seek "predictive" measures (Rander et al, 2007). These measures should show what is going out of control, before too much damage has been done. The identification and/or development of "predictive performance measures" will prove of great value to the research and practice of the performance measurement field.

Performance measurement is an essential element of effective planning and control. However, the degree of effectiveness of any control strategy will depend on the adequacy of the metrics deployed. The traditional accounting-based measures have been relied on for a wide range of managerial monitoring of organisational performance. However, the author believes and literature supports (Syamil et al, 2004) that these measures are generally less than satisfactory for a number of organisational activities such as the New Product Introduction process.

The changing business and competitive environment requires firms to introduce new products more frequently and in a shorter time. This also means that organisations have to be agile as well as responsive to the changing needs of customers. Therefore, for the design managers to operate effectively, it is absolutely essential that there is a continued availability of high quality information.

However, as a basic fact (Calabrese, 1999), information in product development is often incomplete, of low quality or inconsistent because the product is still under construction. The author has also witnessed this throughout her industrial experience. The underlying reasons for the resulting decisional problem are inherent within the concurrentness of the product development process. Marketing wants to delay decisions about product features until close to the product launch date in order to be able to react to the latest customer needs. This is one of the benefits of faster time to market prior to the concept becoming outdated. On the other hand, the design and manufacturing functions want to 'freeze' option choices as early as possible for better planning and co-ordination. Further, the effects of late changes to the product specification are difficult to estimate. This situation has imposed a considerable pressure on product design managers as their decision-making capability is seriously impeded. Thus, they have a strong need for reliable information to assist them in reliable and accurate decision making.

The structure of this chapter includes an introduction to performance measurement from an NPI perspective. The following comprises a review of the contemporary literature on the subject and an outline of current practices based on results from a number of published surveys on multinational companies. The general trends of measures used for NPI will also be identified.

4.2 Measuring the Performance of the NPI process

4.2.1 The Current State of Performance Measurement in NPI

Performance measurement has been an essential element of management control for a number of years. Until recently, the only measures consistently produced were for financial records. However, financial performance measures are more useful at the higher levels of management where they can reflect the success of the business strategies. According to Johnson (2002), the relevance of measures to business objectives and particular processes was lost between the 1950s and 1980s when management used cost accounting to drive marketing strategies and control operations. This view is also supported by Dixon et.al. (1990) who considered that cost-based measures are inconsistent with the emphasis on quality, JIT and the use of manufacturing as a competitive advantage.

Activity based costing (ABC) was initially hailed as the answer to all the problems of accounting systems. It is widely agreed that ABC should be used as a tool for decision making rather than as a replacement for an existing cost accounting system (Letza et al, 1994). Financial measures alone cannot adequately reflect non-financial factors such as quality, customer satisfaction and employee motivation. Linking development, operational and financial measures, more meaningful and useful results can be obtained. To date, insufficient attention has been directed towards this activity.

Activity in the area of concurrent engineering and performance measurement, on the other hand, has increased enormously in the last few years (Driva et al., 1999). Notable work on the subject includes that by Gregory (1993), Hronec (1993), Globerson (1985), Sink and Tuttle (1992). One of the most comprehensive global investigations of product introduction and management practices has been in the automotive industry. The conclusions recorded by Clark and Fujimoto (1991) and by Womack et al. (1990) stated that the auto industry example has far-reaching implications that will touch all R&D manufacturing organisations. However, they do not extend their research to the point of proposing a system of performance measures. One of the first studies to focus specifically on NPI was carried out in Canada by Richardson and Gordon (1980). They surveyed 15 manufacturing firms following up with interviews and a study of case literature in manufacturing policy. From this they reported that the traditional performance measures used by these firms inhibit innovation, with the measures focusing on the plant as a whole rather than individual products.

Performance measurement research to date has been confined primarily to financial metrics, with some recent developments for manufacturing metrics by Maskell (1991), some organisational (Neeley et al, 1995) and business measurement systems (Black et al., 1998). Some research has been carried out in product development but this has focused on complexity, success and failure aspects (Griffin and Page, 1996) and on strategy aspects (Barczack, 1995). Currently (Rander et al, 2007), more and more attention is paid to assessing the nature of the relationship between business performance, organisational intellectual capital and knowledge management (Hansen et al., 1999).

According to Koliza et al. (2004), there appears to be a lack of a cohesive methodology presently available for assessing performance during product introduction applied on a consistent rather than on an ad hoc basis. Measures need to be introduced specifically targeting the performance of the NPI process. These measures should provide "predictive" data so that action can be taken before the effects of the issues identified become detrimental to the overall performance of the business.

A degree of freedom and flexibility is an essential ingredient to productive cross-functional NPI teams. Managers are faced with the challenge of institutionalising effective control mechanisms which lead the process in the right strategic direction and monitor progress toward organisational and project goals as well as allowing for adjustments in the process if necessary. According to a research carried out by Bonner et.al. (2002), too much or the wrong type of control may constrain the team's creativity, impede their progress, and injure their ultimate performance.

4.2.2 The use of quality tools and techniques in product introduction

An examination of the strength of relationship between innovation and continual market prosperity was one of several projects on success in NPI and innovation that have been carried out by Hart (1996) at Stirling University (Johne and Snelson, 1990). She reported that NPI success is often derived from overall company performance, which can be misleading. Mahajan and Wind (1992) carried out one of the few surveys of tools, methods and "models" used for measuring NPI. The main aim of this research was to determine the role of new product "models" in supporting and improving the NPI process. Marketing activities before and after product development (i.e. detailed market study for market identification, positioning and strategy, pre-market identification, positioning and strategy, pre-market volume forecast, market launch planning, etc.) were the main focus of that research. However, the study revealed that there was limited use of "models" and methods (including focus groups, conjoint analysis, Delphi, QFD and product life cycle models) among the respondents.

The use and application of quality tools and techniques within an effective problem solving methodology are essential to understand and facilitate improvement in any process. This is followed by the application of appropriate controls and performance measures to sustain and advance the improvements that have been made. The new product design, development and introduction process is no exception. However, research carried out by Spring et.al. (1998), has shown that NPI practitioners do not make full and/or efficient use of the tools and techniques available to them. Tools such as the seven quality control tools (Pareto analysis, cause and effect, control charts, checksheets, histograms, scatter diagrams and stratification) described by Ishikawa (1986) are usually perceived as contributing little to the introduction process. Lamb and Dale (1994) have also identified a reluctance to utilise those techniques that have direct application to the NPI process such as Quality Function Deployment (QFD), design of experiments, fault free analysis, and Failure Mode and Effect Analysis

(FMEA), many of which have been specifically developed to improve this process. Whilst a number of companies use these tools for technical risk analysis few use it for other risk types and even less take the results into account when planning the development process. The author believes and her industrial experience supports that these techniques are not utilised due to time constraints and the underlying culture of the functions that are required to carry them out. They often believe, maybe not rightly so, that these techniques are additional tasks that do not contribute anything towards the product development activity. The development of a strategic plan for the implementation of tools and techniques to NPI is lacking in the vast majority of organisations.

Findings from research into the management of the NPI process (McQuater et.al. 1996) indicate that when tools and techniques are effectively used in the process, design intent is planned into the product, problems are identified earlier, designs are produced at a faster rate, and the designs and products are more cost effective to produce. Concurrency in development is necessary but created control problems as the process encourages non-sequential activity that unsettles functional managers. Managers may prefer the global release of information that reduces change control problems according to the guidelines of the ISO 9000 and QS9000 standards.

The author has observed that there is reluctance in the use of controls and performance measurements by a considerable number of functions involved in the NPI process. The author suggests and literature supports (Thia et al, 2005), that when a performance measurement system is designed for the NPI process the organisation's culture, product nature, timescale pressures are taken into account. Thus, the performance measurement system in order to be accepted needs to be flexible, user friendly and most of all useful.

4.2.3 Types of performance measures currently used

Driva et al. (2000) carried out detailed research among ten companies. The research revealed that the most widespread measures among the ten companies were the monitoring of the number of projects completed per annum (80 per cent), the number of field trials prior to production (80 per cent), the actual versus target time for project completion (70 per cent) and the number of new products released per annum (70 per cent). The preferred frequency of reporting was almost evenly split between monthly and per project. Table 4.1 shows the performance measures that were quoted to be used by the companies investigated. The Product Design Specification (PDS) as defined within BS7373 and BS7376 requires that attributes be identified with measurable performance and tests identified to confirm compliance.

This table clearly shows that time and cost are the most widely used indicators. What is surprising is the lack of quality measures in the majority (90%) of the organisations. This could be due to the fact that quality related issues can be very difficult to measure and define. Their nature is often "soft" an attribute that adds to their complexity.

Table 4.1: The most important performance measures used

	No of Companies
Time	
Average time to market	2
On-time delivery of NPI	3
Schedule Adherence	3
Cost	
Total project cost against budget	4
Profitability analysis – performance against objectives	2
Product cost	1
Actual to predicted profit on products	1
Product development cost as percentage of turnover	1
Margin analysis	1
Quality and Customer	
Number and nature of engineering change requests per project	1
Adherence to original product specification	1
Field trials	1
General	
Percentage sales from new products vs total sales	1
Number of new product releases per annum	3
Number of successful development projects vs total number of projects	2
Money generated by new products over first two years vs total sales value	1
Number of products taken up (from project portfolio) vs total number available	1

Source: Driva (2000)

Some firms are operating with a fairly basic set of measures that monitor the overall picture of time, cost and quality whereas others have a more comprehensive set of measures (Tangen, 2003). The author's observation is that there is varying emphasis on the type of measures used according to the industry and the marketplace. For example, cost may be insignificant compared to time to market while in other industries new innovations may be of lesser importance. In this scenario, ensuring that the new product adds to the company's overall profitability is the most important measurement as continued growth is a prime business directive.

The author also supports that some of the companies are affected by strategic measures from corporate headquarters, e.g. Economic Value Added (EVA) and other measures required for reporting to the shareholders. EVA in particular is a case of a compound measure that aggregates data to provide an overview for senior management and executives (Mouritsen, 1998). These measures may be out of step with the operational measures advocated by designers and engineers, owing to their exclusion of non-financial factors. Hence, the author argues and literature supports (Cooper, 2001) that to achieve a set of mutually acceptable and consistent measures requires a greater emphasis on designing measures that reflect the NPI process and the overall business objectives. In principle, a mix of measures is often desirable that focuses on both the NPI process and the output to permit evaluation of tangible and intangible assets of the organisation. This mix usually comprises hard measures (i.e. quantitative values) and a set of soft measures. A balanced approach to measures permits appropriate attention to internal efficiency and simultaneously encourages creativity, innovativeness and collaborative working (an essential principle of concurrent engineering) during the NPI process. On the other hand, this approach could lead to more talk than action, design by committee, less innovation, increased risk while reducing the purity of a single vision.

The particular value of soft measures lies in identifying potential problems as well as addressing wider issues such as utilisation of intellectual capital and designers' experience and knowledge (Klein, 1998; Hansen et al., 1999). They are also useful as benchmarks to replace hard measures where they are not comparable between one organisation (or division) and another because of differences in, for example, product development stages or processes. Soft measures are being used to varying degrees at different companies. In contrast, one of the most difficult but important measures is the time taken for product development. The author has recognised through her industrial experience that measuring engineers' and designers' time using time sheets for each project is an unsatisfactory but commonly used method. It gives a "ball park" figure as an indication of how many hours are spent on a project but it is unpopular and can be misleading and open to interpretation. The hours booked may be necessary for costing but is not a good indicator of progress made. Arguably, this type of measure can suppress designers' creativity and innovative potential.

Lack of consistency has been observed in the application of measures, together with the fact that in some cases results are not fed back to practitioners of the process measured. A number of companies have formal written information on performance measures available but it is either dispersed across several departments (and data formats) or held on one manager's computer. Currently, the majority of firms use traditional tools and techniques for communicating measures, but there is a strong desire to use the latest electronic means for this purpose. One major challenge will be to unite all such data onto a central (networked) database to allow for greater visibility. This initiative is the focus of a European funded project (CODESCO) currently under progress at the Centre of Concurrent Engineering, University of Nottingham. In CODESCO it is proposed to develop a "dashboard" to support communication and decision making when managing concurrent product development. According to the CODESCO final report (2000), the CODESCO environment was applied within pilot projects at the industrial partners for validation of the approach.

4.3 Conclusion

By reviewing the literature and research in the area of performance measurement in the NPI process the author concludes that:

- There is a lack of a measurement system presently available for assessing performance during product introduction.
- Currently available tools and techniques that assist in the control and monitoring of product development activities such as QFD, balanced scorecard (Kaplan and Norton, 1992) and diagnostic tools (Dixon et al., 1990) are not used consistently throughout the product introduction process.
- Measures of performance in product design and development are primarily internal measures that focus on comparing activities and processes to previous operations and targets. The comparative nature of these measures does not allow them to be used as dynamic "predictive" measures. These measures tend to be used at the end of the project when quite often it is too late to act.

- There is no one set of measures that will remain definitive over time. Performance measures, as with the organisation itself, should be flexible to change.

A number of strategic level measures of NPI performance need to be identified that will monitor the efficiency of the process while providing an early warning of potential problems. However, there is a lack of systems in place to support this kind of measurement. This could prove a major barrier to the implementation of a new performance measurement method. As the number of projects increases the data collection task becomes even more cumbersome and the cost of data collection becomes more significant. To alleviate this issue automated data collection systems could be implemented alongside the performance measurement system that will simplify the task.

Properly designed, planned and introduced situation-specific measures can help to reflect the contribution NPI makes to overall organisational competitiveness.

Chapter 5

5. SUMMARY OF FINDINGS

5.1 Introduction

Reviewing the chapters presented to this point there are a number of issues that can be identified regarding concepts such as NPI, time-to-market, performance measures and their interrelationships.

This chapter briefly summarises the findings and issues identified from the investigation carried out on the NPI process. The significance of time-to-market and its effect on business strategy and profitability is summarised here. The lack of performance measurement within the NPI process is also identified.

Finally, the conclusions highlight the most important issues identified by this research project. A proposal will be presented at a later stage (chapter 8) that will attempt to improve and where possible resolve the problem areas investigated in this chapter.

5.2 Overview of Current Literature and Current Findings on NPI

The introduction of a new product is one of the most important processes carried out in an organisation. Part of this process is New Product Introduction and Development (NPI/D). There is a growing realisation of the dependency on this process and an increasing recognition of its contribution towards company growth in all industries. This has been realised not only by those actively involved with this process, such as designers and programme/project managers, but also by manufacturing and marketing personnel. According to Jones (1997), as the status of NPI/D activities increase, the need to support this process with various tools and techniques is becoming increasingly acknowledged.

NPI encompasses the development of new products or modifications to existing ones, driven by market needs. Delays in the NPI process potentially lead to extended time-to-market if they occur or influence the critical path. Time-to-market is an important measure of the performance of an organisation, together with productivity and quality. Many companies attempt to reduce the time-to-market of their products and services in order to increase their competitive advantage. Being faster to market enables a potentially greater market share and higher price realisation. Also, a long development process exposes the project to the risk of changes in the market and environment, particularly when product lifecycles are short. Product modifications and replacements also need to be managed more effectively if market share and profits are not to be lost. (Stalk & Hout, 1990, Wheelwright & Clark, 1992)

There are several generic factors that contribute to extended time-to-market, irrespective of the type of industry or target market. Prioritising these factors in a given organisation can prove a complex and time-consuming activity. Formulating a measure that allows us to quantify the losses caused by delays in the process would allow the identification of the most significant of such delays and their effect on the company's profitability. Thus, actions can be taken to improve the company's performance.

The NPI process is increasingly of a crucial concern for a considerable number of companies. Survey results carried out by Wilson et al (1996) indicate that one-half of a company's revenue comes from sales of products that were not in production ten years ago. Griffin (1997) agrees that the proportion is expected to increase beyond 53% of sales for the years to come.

From the literature, it is obvious that great effort has been placed upon product success (Johne & Snelson, 1988; Cooper, 1992) and product innovation (Pavitt, 1991). Many beneficial design and manufacturing methodologies have been applied in recent years to improve product quality and throughput such as Design for Assembly and Disassembly, Design for Manufacturing, Computer Aided Design and Manufacturing, Design for Desirability (ISO14000). However, even if these individual methodologies are executed perfectly, the resulting products may still fail to win customers. Wilson et al (1996) states that "the goal for a successful NPI process should be to create a product that provides the maximum value and quality to customers in the shortest possible time".

An important aspect of an effective NPI process is that it should not be static, it should change and become more advanced to maintain market competitiveness. Interestingly, although the need for an established NPI process is evident, a third of the firms monitored by Belliveau in 2002 still use no formal process for managing the introduction of new products to their markets. The PDMA's (Product Data Management Association) survey in 1990 revealed that only 54.5% of the firms had a well defined NPI process that increased to 60% by 1995 (Griffin, 1997). The results from these research activities verify the trend that companies since the 90s started to focus more on their NPI processes.

It is vital for companies to realise the importance of the NPI process and invest resources to develop the most efficient sequence of events for a successful introduction of a product or service related to customer satisfaction and response time. The author argues that there is no standard

NPI process that can suit all businesses. Different processes evolve for different industries, according to their particular needs. The author would like to point out that the need for control, against the need for speed, would need to be evaluated in each case for different companies. However, the author observed that some similarities do exist and most processes follow the same pattern. The British Standard Information series have published generic Design Management System Guides (BS7000).

5.2.1 The significance of Time to Market

The term time-to-market is used to encompass the notion of speed in introducing new or improved products and services to the market place. However, it is more than just *time*, it is also time-to-money, including the "dimensions" of Quality Performance, Cost, Resources, Customers, Suppliers, and Competitive Advantage. In an example given by Stalk & Hout (1990), it has been estimated that in the electronics industry, introducing a product 9 to 12 months late can cost a company 50% of its potential revenues.

If a company is late in getting its products to market compared to its competitors, the effect will be felt on its costs, its revenue and therefore its overall profitability. If the development process takes longer than expected or even worse, longer than competitors, two effects are likely to surface.

- The first is that the cost of development will increase through the use of additional development resources such as designers; development period usually increases the costs of development. In addition to this there is also the lost opportunity for other development projects that could have utilised the same resources.
- Secondly, and perhaps more seriously, the late introduction of the product or service will delay the revenue from its sale (and possibly

reduce the total revenue substantially if competitors have already got to the market with their own products or services), and strain the company's cash flow. The net effect of this could be a considerable reduction in sales and reduced profitability; an outcome that could considerably extend the time before the new product or service is profitable (Slack et.al., 1998).

The author supports that although time to market and a product's profitability are closely linked, simply increasing the speed of the NPI process is no guarantee of success either. In fact, haphazardly adopting the numerous methods for accelerating NPI may jeopardise the potential success of the new product and company. Companies seeking to speed up their NPI process should take a hierarchical approach to implementing the various techniques. In order to improve the benefit of an accelerated NPI process it is recommended that a company should start by focusing on simplification of the process. By doing so the company can proceed with techniques involving the elimination of unnecessary steps in the process (Commandeur, 1995).

5.2.2 Performance Measurement of the NPI process

Typical measures of the NPI process and time-to-market performance include frequency of new product introduction; number of products started and completed (actual versus planned); and the percentage of sales resulting from new products (Wheelwright & Clark, 1992).

Historically (Driva et al., 2001), accounting-based measures have been relied on for a wide range of managerial monitoring of organisational performance. However, they are generally less than satisfactory for some organisational activities like new product development and introduction.

Mahajan and Wind (1992) carried out one of the few surveys of tools, methods and "models" used for measuring NPI. The main aim of this research was to determine the role of new product "models" in supporting and improving the NPI process. The study revealed that there was a low usage of "models" and methods, showing that no notable effort has been made in measuring the performance of the NPI process.

The author suggests and literature indicates that performance measurement research to date has been confined primarily to financial metrics, with some recent developments for manufacturing metrics by Maskell (1991), some organisational (Neeley et al, 1995) and business measurement systems (Black et al., 1998). Some research has been carried out in product development but this has focused on complexity, success and failure aspects (Griffin and Page, 1996) and on strategy aspects. Recently, more and more attention is paid to assessing the nature of the relationship between business performance, organisational intellectual capital and knowledge management (Hansen et al., 1999).

The author supports that there appears to be a lack of a methodology presently available for assessing performance during product introduction using concurrent engineering principles and applied on a consistent rather than on an ad hoc basis.

5.4 Conclusions

This research project is involved with the NPI process, its relevance to time-to-market and the measures that evaluate its performance. Based on the literature reviewed in chapter 2 to 5, the author concludes that:

- A generic NPI process cannot be successfully applied to all organisations. The process needs to take into consideration the product or service provided, the customer as well as the environment and the market (sector, region and geographical markets) the company operates within. It is important for firms to identify their own unique process, based upon their own business characteristics, which can be flexible and adaptable.

- Time-to-market is a primary measure that influences the success of the NPI process. In today's strongly competitive and fast moving environment there are a large number of benefits to be realised by a fast first, and sometimes second, entrant to a new market. Companies are striving to remove all obstacles that could potentially delay their product introductions. However, care needs to be exercised so that valuable steps are not skipped and unnecessary risks are not taken in the name of speed.

- Finally, the current measures for assessing the performance of the NPI process are too generic and tend to provide information at the end of the process, when quite often it is too late to react. Although, generic financial summaries and measures provide valuable information, they cannot control the business processes across a company's spectrum. Effective decision-making requires direct quantitative measures of operational systems feedback and improvement. It is important that a performance measurement system is developed to cater for the specific attributes of the NPI process.

The issues identified above form the basis of the "problem" identified by the author in this research project. The author believes that it is important and critical for practitioners of a NPI process to follow a well defined process suited for the specific company characteristics. With the use of a measurement method the effectiveness of the process can be assessed. Subsequent chapters will address this issue and will offer solutions to improve the current status and assist practitioners to avoid situations that could lead to irreversible outcomes. The following chapter will describe the research methods utilised to validate the "problem" identified from the literature review.

Chapter 6

6. RESEARCH METHODOLOGY

6.1 Introduction

This chapter describes the research philosophy that was followed in this investigation. It outlines the strategy used, describing the original methodological design, whilst explaining how it evolved with the adoption of a number of different approaches. An overview of these methods will be given covering their objectives, sequence and timing. The practical details of each method and the main research tools are also covered.

The steps taken to test the research conclusions will be discussed in a later chapter, after the research findings are presented and discussed.

6.2 Research Philosophy

As stated previously (section 1.2), one of the main objectives of this research is to assess the use of performance measurements to evaluate the effectiveness of the NPI process. To address this statement an approach based on the development of grounded theory, which is a combination of quantitative and qualitative methods, was chosen. The reasons for doing so where:

- The subject of this research is very much exploratory. Therefore, an inductive method (Martin and Turner, 1986) is preferable to a deductive one. Grounded theory is well suited for "problems" of this nature since data is systematically collected and analysed. It is an iterative process that can develop context-based, process-oriented descriptions and explanations of the problem.

- The other methods available follow a deductive approach and are not suitable for this type of research. The number of variables to be taken into account is so large that an "experiment" cannot be designed to review this "problem".

- Grounded theory has proven to be a very successful method by a number of researchers, studying subjects of a similar nature such as the application of Continuous Improvement within a number of processes including new product development, customer satisfaction and human resource management.

6.3 Research Strategy

New Product Introduction processes vary greatly amongst companies, and aspects of both process and performance measurement can be undocumented and ad hoc. These factors suggested that a combination of quantitative and qualitative research methods would be more likely to produce a valid understanding of the issues to be investigated due to the fuzzy nature of the process.

The original research strategy was to start with literature review that would help to shape a number of questions for a survey to be posted to practitioners across a number of companies. This was to involve organisations with different characteristics such as size, market, industry, and complexity of products. This phase was to be followed by an additional questionnaire to obtain more detailed information from a selection of the survey respondents. A semi-structured interview was to follow to validate and evaluate the information provided. The companies were to be selected from those that positively responded and were recognised as having experience and expertise in the area of NPI. The main objective of these interviews would be to establish the level of measurement of the NPI process within the respondents' companies and the measures or systems most commonly used. The areas to be covered as derived by the aims and objections (section 1.2) would be:

- the characteristics of the business that may influence the NPI process;
- the sensitivity of the current NPI process to those company characteristics; and
- the company performance measures used to evaluate the performance of the NPI process.

The data collected was to be analysed and verified through the production of graphs, diagrams and process flow charts.

Before starting the research certain methodological concerns were identified such as the intangible nature of the subject of performance measurement of the NPI process and access to the target population. Companies that may be involved in NPI activities might not have a clearly defined process making it difficult for respondents to understand the questions asked. For these reasons it was decided to narrow down the target sample population to companies that did have a good understanding of their NPI process, formal or informal, and study them in more detail.

6.3.1 The approach

No single research method can provide a study with all the information and data required. A variety of methods were adopted in this programme in order to approach the problem from different directions and help to create a consolidated picture of the issues involved. As the project evolved several opportunities arose that led to the use of these methods hence strengthening the research done.

From the initial response of the postal survey there were 8 companies that provided adequate data by answering the questions in full. These companies were also willing to offer assistance and further information where necessary. Therefore, these responders fitted the criteria set for more detailed research and analysis. These criteria include the completeness of the data provided, the industry the companies belonged to, their experience of the NPI process and their relevant process quality standard achievements. These 8 companies studied would allow an analytical as opposed to statistical, generalisation. According to Yin (2002), analytical generalisation occurs when "*a previously developed theory is used as a template with which to compare the empirical results of the case study. If two or more cases are shown to support the same theory, replication may be claimed.*"

The 8 companies studied in detail also represent very different organisations in respects of their size, market, industry, ownership, product complexity and technologies. Their commonality is that they all delve into introducing new products to their respective markets by utilising a NPI process. It should therefore be possible to assess the processes utilised as well as establishing what kind of measures are used to evaluate the performance of the process.

A further advantage in reducing the number of the sample population is that it is possible, due to the time required, to study in more depth the companies involved. Due to the complexity of the topic and in order to build an accurate picture further information will need to be obtained. The follow-up interviews, that were planned to follow the survey, assisted greatly in the information gathering and clarification activity.

6.3.2 Overview of methods used

The main methods used fell into three categories: preliminary interview, postal survey, detailed interviews and a case study. Each method had its own distinct objectives to satisfy the three main areas as discussed on page 98:

Preliminary interview to:

- review some actual NPI processes;
- review some actual performance measures of the NPI process; and
- explore the potential of a performance measure specifically designed for the NPI process.

Postal survey to:

- identify the status of the NPI process within the respondents;
- identify the characteristics of the companies in relation to their NPI process;
- identify their vulnerability against process delays depending on their company characteristics;
- identify the companies with potential for further review; and

- gain quantitative data to be used in order to test and evaluate the proposed performance measurement method.

Detailed interviews to:

- identify performance measures currently used throughout the NPI process;
- identify if practitioners are satisfied with current measures used; and
- identify actual or potential barriers to implementing a new performance measurement system for the NPI process

Case study to:

- test the applicability of the performance measurement method proposed;
- evaluate the company characteristics that influence the results achieved; and
- identify factors that can assist or inhibit the implementation of such a process within an organisation.

An ethics and a confidentiality form were signed prior to any contact with any of the subject companies therefore, the company and contact names will not be mentioned in this document.

A schematic view of the process followed is illustrated below (figure 6.1).

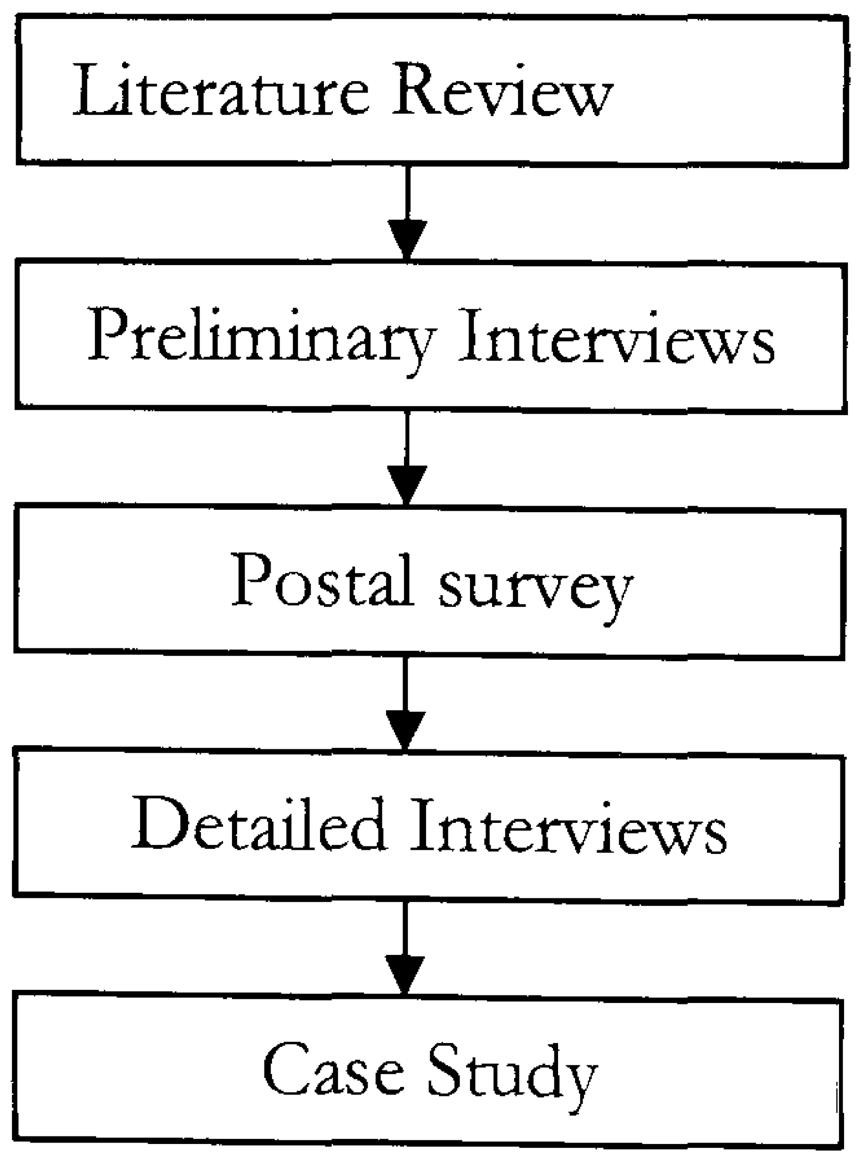

Figure 6.1. *Sequence of research methods used*

6.4 Execution of the Research Methodologies Selected

This section offers details of the research methodologies utilised to explore the application of performance measures within the NPI processes. The information is relevant to the execution of the methods used throughout this research project. The conclusions from the use of these methods will be evaluated in the following chapter (chapter 7).

6.4.1 Preliminary Interviews

The preliminary interviews were carried out in two different companies. These companies were selected due to the researcher's access to personnel and data at the beginning of this project. Appendix 1 contains the names of the companies involved. Their identities are to remain confidential in any other document prepared and published as a result of this study.

Company A

Company A is a medium sized company manufacturing detection equipment for a number of different chemical and biological agents. In 2003 the company had 350 employees and a turnover of £50M. The author was a full time employee of this company as a member of the Business Improvement Team, which offered an excellent opportunity to carry out detailed review and analysis of the NPI process. The company operates on an Engineer/Make-To-Order principle. Thus, new products were always in the pipeline providing a number of potential development projects to be followed throughout the process. The development project selected for review was Product X. Product X is representative of the type of products that the company developed. The first order for product X was received early in 2003. Development of the product started shortly after the receipt of the order, manufacturing followed on after the completion of the development project in 2004 for a scheduled delivery to the customer early in the following year.

In September 2003 the author was tasked to assist participants in the product X project to review the current loosely documented NPI process and where possible introduce new procedures that would improve the process and the performance of those involved. This study provided different perspectives of the process and a number of points were identified that could be of use in the development of new products to follow.

The lifecycle of the development for product X was followed from early conception to order fulfilment and subsequent support. Semi-structured interviews were carried out throughout this period (2003 – 2004) with 4 key staff: Programme Manager, Project/Resources Manager, Sales Manager and Senior Design Engineer.

Due to the informal nature of the interviews that took place, interviewees were able to elaborate and provide additional information, as they felt necessary. The interviews took place at regular intervals (one every month) in order to cover the breadth of the project. All 4 key functions were brought together in order to observe interactions and collect comments on questions relevant to all.

The purpose of these interviews, derived by the objectives on page 101, was to review standard NPI processes found in literature and assess their suitability to Company A based on the unique company characteristics. The development of a new process followed that took into account the company's project nature, culture, customer base and market.

Company B

Company B is again a medium sized system and avionics manufacturer that provides electronic products for various aircraft. One unstructured interview was held with two individuals who were members of the design and engineering team involved in most major development projects. The company had recently undergone an exercise in which a new NPI process was developed and was currently in the early stages of its implementation.

The interview revealed that the existing process was not adequate based on the experiences of those involved. This led to the initiation of a review team that finally developed the new process. The meeting took place in Midlands UK and lasted approximately 4 hours.

The purpose of this interview, derived from the objectives on page 101, was to identify issues with the NPI process in use at Company B. The causes of these issues and their possible solutions were also discussed.

6.4.2 Survey

In 2004 the author carried out a survey to assess the NPI status and its measurement methods (based on the objectives on 101), of international and UK companies that were providers of new products and services to their respective markets. The purpose of the survey was to obtain information regarding the NPI processes in use and to identify potential issues with current practices. The survey was also intended to provide the author with quantitative data on the issue of the impact of delays throughout the NPI process and time-to-market.

The survey instrument comprised a six-page questionnaire (Appendix 2). To enable intra company comparisons a set of core questions that the author produced were agreed between the researcher and the project supervisors. However, respondents were able to add further information as required within a dedicated *comments* section.

The questionnaire comprised four sections:

- section 1: company details and background;
- section 2: the NPI process used within the organisation;
- section 3: the company's environment and characteristics that influence their NPI performance; and
- section 4: general comments.

There were a total of 28 structured questions. The questionnaire was mailed to the companies found in the University of Hertfordshire contacts database due to their willingness to co-operate in other university projects. Due to the strategic background of this research and the questionnaire prepared, the study would have benefited from the input of the Engineering Manager or the Sales & Marketing Manager involved in the implementation of new products and services to the market. The questionnaire was addressed to these functions. The initial response was slow and the decision was made to further e-mail the questionnaire to the members of the Just-In-Time club since the subject of NPI is often discussed in this forum. This made a total of 200 companies involved in the postal survey. However, this did not assist greatly and the total number of valid responses was reduced to 8 (including the responses produced by the companies involved in the preliminary interview stage).

The data collected was entered onto an excel spreadsheet. The analysis of the results and the production of an initial report was carried out after this exercise (chapter 7).

6.4.3 Follow up Interviews

The valid responses from the survey, based on cross reference and completeness of the information provided, coherent data were screened and were used to establish contacts so that detailed interviews could follow in order to collect specific data to verify and elaborate on what was already collated. The respondents of all the 8 companies (appendix 1) were contacted individually and a time was set that was appropriate for each participant for a telephone interview to take place. The duration of the telephone interviews were approximately one hour. The objective of these interviews was to evaluate the data provided on the questionnaire responses as well as to establish the level of performance measurement within the company and the NPI process. The questions asked addressed the following subjects in order to provide necessary data against the aims and objectives of this research (section 1.2):

- background to the NPI process followed in the company;
- strategy for the NPI process;
- changes to the NPI process;
- organisation, management and operation of the NPI process;
- nature of changes made to the NPI process;
- lessons learnt;
- performance measurement of the NPI process.

Other sources of information included documentation such as presentations, briefing notes, company documents and flow charts. A description of the companies involved follows, with the exception of companies A and B whose profiles were reviewed in section 6.4.1.

Company C

Company C was a global company dedicated to providing office solutions. It was founded in 1906 and underwent a number of changes throughout its life. This is a company that invests a considerable amount (circa $900M, about 6% of its revenue) in research and development of new products as well as new services. It employs over 70,000 people world-wide and it is a market leader within its industry. In 2000 after constant pressure from the increasing competition the company underwent an improvement programme with the implementation of six sigma throughout the organisation. Since then, the company has managed to improve its processes leading to a significant comeback over the last 6 years.

Company D

Company D is a company that emerged from the merger of two organisations in the early 1930s. One of them had a very strong record of innovation that has been reflected in the company's processes. This strong record continues until today with the development and introduction to the market of a number of world first-off products. Company D offers measurement systems and test equipment to its market.

Company E

Company E is a well-established company that undertakes innovative projects with mostly military applications. Its products are focused on the delivery and support of advanced defence and aerospace systems. This company is a member of the Engineering Excellence Programme and employs a large number of engineers across 130 countries.

Company F

Company F was founded in the 1970s in the UK and managed to achieve global status by 2003. It supplies its market with inkjet and laser printing technologies and solutions. It has a reputation for continuous development and production of very reliable products. A lot of effort has been invested in the research and development function that led to setting new industry standards in quality and reliability.

Company G

Company G is a new global company created through the consolidation of two companies involved in electricity, water and gas metering systems. This company is currently the market leader in electricity and water metering systems and load control solutions. It has a wealth of knowledge and experience in the products it develops. It also has a tradition in developing and manufacturing products and services that use cutting-edge technology.

Company H

Company H specialises in the design, supply and support of innovative advanced instrumentation for industry, research and educational institutions and centres of health care. The aim of this company is to be the leading provider of tools and systems for the emerging nano-technology markets. To achieve this, great effort has been put into the identification of new technologies and innovative new products.

6.4.4 Case Study

The details of the case study carried out in Company A can be reviewed on chapter 10.

6.5 Review of the Research Methodologies used

6.5.1 Individual Review of the Methods

The main methods used in this research were preliminary interviews, survey by postal questionnaire and detailed follow up telephone interviews.

Each of these will be reviewed using the criteria that were defined by Gill & Johnson (2002):

- internal validity – the extend to which the conclusions are warranted regarding cause and effect;
- external validity – the extend to which the conclusions may be generalised; and
- reliability – review the consistency of the results obtained

Preliminary Interviews

In the preliminary interviews a proportion of the comments were based on observations and direct involvement in the companies' processes. This increases the internal validity of the information. This method did not lend itself to external validation since only two companies were involved. However, at this stage of the research this was not a major issue since the primary role of these interviews was to generate the hypothesis upon which the project was to build. The interviews contributed an in depth perspective to the emerging hypothesis, which otherwise drew on literature and academic research. The similarities between the preliminary interviews and the reported research in the subject area also indicated that this initial work was considered to have a degree of reliability.

Survey

Surveys enable researchers to reach a number of companies for relatively little expenditure in terms of cost and time. However, this advantage is gained at the expense of the quality of the data collected.

It is probable that a proportion of the comments and the responses made were probably based on personal theories derived from the participants' own beliefs, readings, and observations rather than established company facts. This in itself would reduce internal validity. Despite the low response rate of the questionnaire (approx 5%), the participants represented a variety of sectors that added some external validity to the method used.

Non-respondents were not followed up due to time and cost restrictions, so it is not possible to guess whether their responses would differ significantly from those obtained. This fact may reduce the overall external validity of the data.

Follow up telephone interview

The relatively low response allowed the researcher to contact all participants for follow up interviews that verified the responses. These interviews in some cases confirmed the data provided although in others it added vital information that was required in order to analyse the statements given. These interviews provide an added degree of internal validity. The external validity of this exercise is also high since detailed interviews were carried out in 8 different companies.

Case Study

Throughout the duration of the case study the analyses from the data confirmed the applicability of the proposed method, suggesting that it has a reasonable degree of internal validity. The performance measurement method proved to be reliable. NPI practitioners from Company A who were able to follow the steps and produce the expected results implemented the method. Details on the case study can be reviewed on Chapter 10.

6.5.2 The methods combined - triangulation

Each of the research methods used in this research has its strengths and weaknesses. An advantage of using multiple methods is that the particular limitation of one may be compensated by the strength of another. For instance, while there may be doubts about the accuracy of some of the survey responses, the data collected by the follow up interviews adds high internal validity. The relative strengths and weaknesses of the methods reviewed are summarised below on table 6.1.

Table 6.1. Comparison of validity and reliability of methods used

	Internal Validity	**External Validity**	**Reliability**
Preliminary Interviews	High	Low	High
Survey	Low	High	Low
Follow up Interviews	High	Low	High
Case Study	High	Low	High

6.6 Conclusions

The research philosophy has been discussed in this chapter that led the researcher to take an indicative approach based on the development of the grounded theory. The research strategy based on investigation and opportunism led to the application of multiple methods that included hypothesis generating preliminary interviews; a descriptive postal survey; and a detailed follow up analysis of the responses via structured telephone interviews.

It has been argued that the number of companies studied provided the ability to conduct detailed research in greater depth by the use of additional methods. A review of the methodologies has shown that although all methods have certain limitations, their degree of validity and reliability is such that used together it proved possible to generate a valid picture of the scope of applying a performance measurement system to the NPI process. The results yielded by the usage of these methods are reported in the next chapter.

7. RESEARCH FINDINGS

7.1 Introduction

The previous chapter described the research strategy followed for this project and explained the reasons for using a multi-method approach. At the beginning of this research project, the preliminary interviews provided valuable information on the subjects of NPI, time-to-market and performance measurement overall. However, in order to correlate real business data to the literature and other studies, the questionnaire approach was selected to assess the use of NPI models and measures. This method focuses on the responses of the subject companies and determines the perspectives of the participants on the use of NPI processes and indicators to evaluate their performance.

A formal questionnaire was forwarded to approximately 200 companies. From the responses received, a number of companies were contacted and links were established with key personnel (appendix 1). A follow up telephone interview was carried out in order to obtain further information and to validate the data provided.

The rationale for this study is based on creating a factual representation of the subject companies and their use of NPI models and measurements of the process to evaluate their performance. This quantitative analysis should accomplish the following three goals. First, it should provide an overview of the current literature and current findings on the subject as well as report the findings from the responses of the participants. Second, it should interpret the facts based on a comparative reading of the sources relative to the questionnaire outcome. Third, the descriptive research must analyse the trends and attitudes in terms of their commonality.

The responses were in most cases comparable with surveys and studies carried out in the past. However, new data is also presented that shows the changes in the NPI process environment and its practitioners since 2000. Overall, the review of the results and the follow up interviews verify and validate the issues identified.

This chapter will present the data obtained from the research methodologies utilised while deciphering their meaning and relevance towards the NPI process and its performance measurement. The findings will also validate the issues identified and summarised in chapter 5.

7.2 Preliminary Interviews

The initial interviews took place in two companies in which the author had unlimited access to personnel and data. The findings were used at the early stages to formulate the hypothesis for this project. Therefore, the nature of this activity was exploratory. The objectives of this activity were:

- to review actual NPI processes;
- to review the use of performance measurements within the NPI process; and
- to shape the hypothesis and the remainder of the research plan.

Two different organisations were involved in this activity: Company A, a medium sized company that engineers and manufactures detection equipment; and Company B an engineering focused company that develops electronic equipment for aircraft. In the case of Company A meetings/interviews were held every month with 4 key members of the development project of a product running at the time. At Company B one unstructured interview was held with three senior engineers who were involved in most development projects undertaken by the company.

7.2.1 Company A

The product selected to be followed through the development and introduction process was selected purely based on the timing of the activity and was representative of the type of projects that the company develops. Company A introduces new products or variants of existing ones at a steady rate each year. However, the process followed to do so has never been properly documented. This led to delays throughout the process and in certain cases misunderstandings as to what the next step was. The company decided that effort was to be invested alongside normal activities for a formal process to be defined and distributed to all involved.

An initial market review recognised a potential gap in the market and a new product specification was drafted. The new product concept was then floated to the market and a potential customer showed interest to the extent of placing an order. At that point the project was in the hands of one person the Sales Representative that handled all the contact with the customer. In order to please the customer and minimise any potential competition a leadtime was promised to the customer that did not allow enough time for development and manufacture of the product. Furthermore, due to contractual issues and customer constant changes to their requirements, the development project did not start until a number of months later than the order receipt. However, the leadtime was never re-negotiated adding extra pressure to the time left for development and manufacture.

Feedback from the process of negotiations with the customer did not follow through to the Project Manager (PM) and Engineering functions. The Sales Representative continued to personally handle all external communications that provided occasional second hand information to the PM. This contributed to a lack of continuity from the sales and marketing phase to the development phase.

Early on in the project the customer took a long time (about 3-4 weeks in each case) to answer queries and delays in receiving the firm order and final specification resulted in development starting a few months behind schedule. This led to increased development costs since an additional number of engineers were employed and activity was carried out outside normal working hours for the milestones to be met. After this initial stage external communication improved both between the customer and the company as well as the company and its suppliers that now started to be involved as components of the product were identified.

On several occasions during the project those involved suggested a number of ideas that could improve the task that was carried out. Notes of the suggestions were made and a number of them were tried out by the task force members. The successful ideas were documented and started to form part of the NPI process under development.

The project's performance was considered to be moderate. The company managed to develop and produce a product that met the customer's requirements. This was completed within a difficult timescale and although delivery was delayed, the delay was not enough to greatly upset the customer. However, development and manufacturing costs were increased since due to additional resources all the constraints were removed or compensated in order to meet the due date.

Some of those involved in the project enjoyed working on it and thrived under the constant pressure. However, there were a number of people that felt irritated by the chaotic situation and the unrealistic targets that they were given. Overall, all those that worked on the project felt a great sense of achievement when the project was closed. However, everyone agreed that lessons should be learnt from this exercise and improvements should be made to the current process and communication avenues.

The main learning points identified by the task force and the author were:

- The need to identify a realistic leadtime for new products including a realistic estimate for organising the development and manufacturing activities.

- The project team needs to be identified early on and communicate at regular intervals of the project so that no-one is "surprised" by certain developments throughout the project and that data is not distorted by the time it reaches those outside the communication loop.

- A process needs to be defined for records and data to be stored or archived so that it is readily available when needed.

- The suppliers need to be involved early on in the development to avoid unpleasant surprises during the design process.

- A team needs to be brought together to review and improve the current NPI process. Lessons learnt from this exercise are to be included to generate an efficient process.

Company A did commit to resolving its issues by forming a Task Force of 10 individuals that were given the task of addressing the problems identified and defining a NPI process.

7.2.2 Company B

The time of the interview arranged with the Senior Design Engineers in Company B coincided with the completion of a business improvement exercise that reviewed a number of processes. The aim of this activity was to improve the existing processes as well as to define new processes where they did not exist. The overall target of the improvement programme was to increase business productivity at all levels with the ultimate target of improving profitability and market responsiveness.

The members of the cross-functional improvement team identified the need to review and redefine the company's NPI process due to its impact upon all functions and most importantly the customer. The process was not well defined or documented at the beginning of the improvement project, making the task of improving it even more challenging.

Although everyone knew that a process was in place very few of the employees involved in it actually admitted using it. Therefore, the team decided to review historical data of past product developments and introductions in order to identify the actual process followed. They early on realised that the process was in some cases significantly changed from project to project to suit the particular product requirements due to

different customer segment, needs and regulations. This was a very important finding that was taken into account when the new process was defined. Flexibility was built into the process to cope with different product, customer and technology requirements.
The new process also made sure that the internal as well as the external communications were improved for timely and accurate information flows. Gates were introduced between every stage in the process. This was driven by a necessity not only to access progress but also to review the financial commitment required for the next phase.

The activity of redefining the NPI process in Company B took just over 6 months. The team comprised of 8 individuals that covered a number of functions from Sales & Marketing to Engineering and Production. The interviewees were members of the improvement team. They did admit that although the task was strenuous and at times very stressful it was well worth doing.

After the completion of their improvement project Company B managed to define a new NPI process that took into account the specific requirements of their customers, market, products and internal processes, attitudes and culture. The new process has been in use for a short period of time (4 months). However, the users of the process have already identified ways that it can be improved further. The interviewees finished the meeting by stressing the point that processes should always be under review and that they should be improved where possible in order to remain effective.

7.2.3 Conclusions

The preliminary interviews provided valuable experience that was used later in the research both in terms of methodology and content. In particular, the Company A case highlighted issues identified by present research while surfacing new ideas and recommendations that are incorporated in this project.

Although Company A releases new products or variants of existing ones to the market every year there was no set process for taking a new product concept from conception to manufacture. This made it impossible to uncover changes between iterations of the activities followed. Company A operates in both a project-based environment (60% of the company activities based on revenue are project-based activities that may not lead to a physical product) as well as a manufacturing facility (40% of the company activities are carried out in manufacturing). The new product concept was developed in the company's own time-frame. However, the new product itself was not developed until an order was received. This resulted in a bespoke product that needed further modifications in order to be appealing to the wider market.

Company B had already been through a number of poorly organised product introductions and were at the end of the process that company A wanted to embark upon. They had found the task of defining a new NPI process very difficult however, they persevered and they did find the outcome of their efforts very useful for all involved in the process.

Both experiences from companies A and B highlighted the importance of several issues already identified in the literature as having a significant impact on the NPI process. Some of these issues are:

- poor communication;
- data management;
- relationship with customer and supplier; and

- lack of a structured process and a measure that will indicate shortfalls with the current activities.

These areas are worth considering in any future investigation concerned with understanding a company's NPI process and how it might be improved.

7.3 Survey – Data Collection

The method used in order for this study to gather relevant data from practitioners was a structured questionnaire in addition to face to face interviews, telephone interviews, e-mail exchange and written feedback. The survey was designed for information to be collated with respect to the experiences and practice of NPI process models and the significance of time-to-market. This presented the opportunity to generate descriptive data from which it is possible to:

- determine how widespread the application of NPI models are in organisations.
- determine the effect of delays in the process used.
- identify the characteristics that make a company more vulnerable to these delays than others.

The questionnaire comprised four sections covering company details and background; the NPI process within the organisation; the company's environment and characteristics that may influence their NPI performance; section for general comments. It was distributed during the later part of 2003 to 200 companies identified from the University's contacts database and the Just-In-Time Internet forum. Most of the questions asked were of the 5Ws and 1H variety (what, where, why, when, who and how). These key questions helped identify the company practices when it comes to NPI models and helped assess the idea that a systematic process is preferable to an ad hoc one.

The bulk of the detailed data collection process occurred over the course of 4 months between December 2003 and April 2004. The process continued until enough detail was obtained and evaluated to provide representative data for the study based on selected criteria. The response achieved was just over 5%. The companies surveyed were selected due to their characteristics and attributes as well as the fact that they cover a wide range of companies that were significantly involved with new product introduction whilst providing different and diverse products. Following this exercise the statistical information was reviewed and evaluated and a document was created representing the findings in a quantitative format.

7.3.1 Survey Results

The ideas and practices identified by the responses of all these dissimilar companies provided valuable information that enabled a comparison of processes and measurement methods between these industries.

The questionnaire was structured into three sections. The first part explored general data for the companies participating in order to compare company characteristics. The second part targeted their current NPI practices and issues encountered throughout the product life cycle. The third part defined the environment in which the respondent companies were engaged.

General company information formed the first part of the questionnaire. This information was required to obtain demographic information regarding the respondents as well as for grouping and comparing the data provided between the companies.

All of the companies involved have a presence in an international market with business units in the UK (Appendix 3). The majority of them are manufacturing companies, the remainder provide services to their customers (Appendix 3). The main industrial sectors targeted included Aerospace, Consumer, Electronics and Automotive companies of varying sizes. Figure 7.1 illustrates the proportion of the respondents from each sector in this survey.

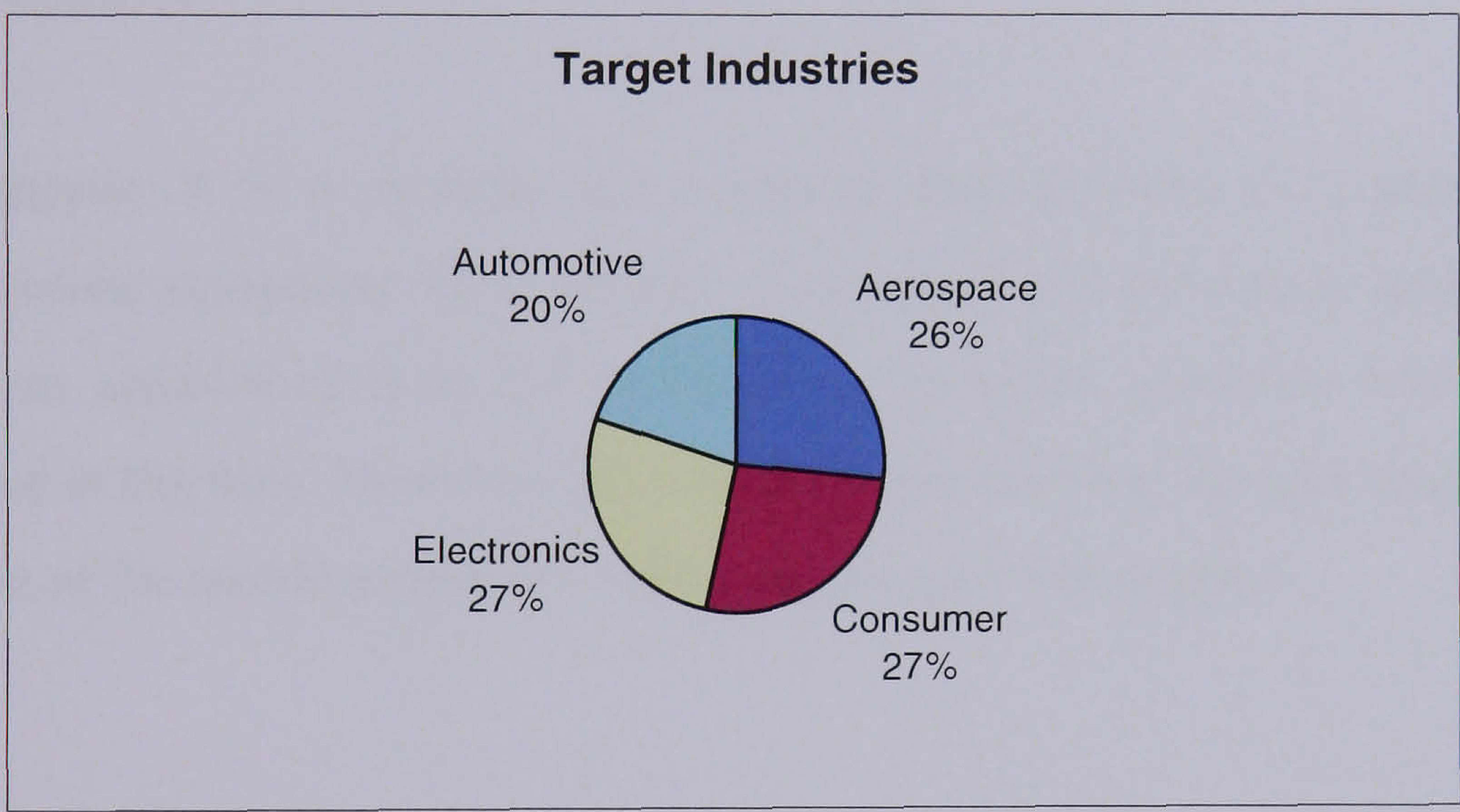

***Figure 7.1**. Industrial sectors targeted in this study (Source: Appendix 3)*

The respondent companies were in the majority (7 out of 8) large in size with employees in excess of 250. The remaining fall in the region of 50 to 250 employees (Appendix 3). The manufacturing methods that the companies utilise also vary between Assemble to Order, Engineer to Order, and providers of standard products and services (Appendix 4). The methods by which parts were produced and supplied were also varied. All of the companies had a strong element of subcontract activities with an equal balance of manufactured and standard parts provision (Appendix 5).

7.3.2 NPI Process Models

Each respondent company was questioned regarding the NPI process that was in use. The following diagrams represent the models claimed to be adhered to by the participant companies. The review of these processes will indicate similarities and differences between the different models used.

Company A

Company A is a medium size company that provides its market with detection equipment for a number of chemical and biological agents. As it was established from the preliminary interviews a process was not in place at the time. However, the company has followed through and by the time of the questionnaire the following process was in place.

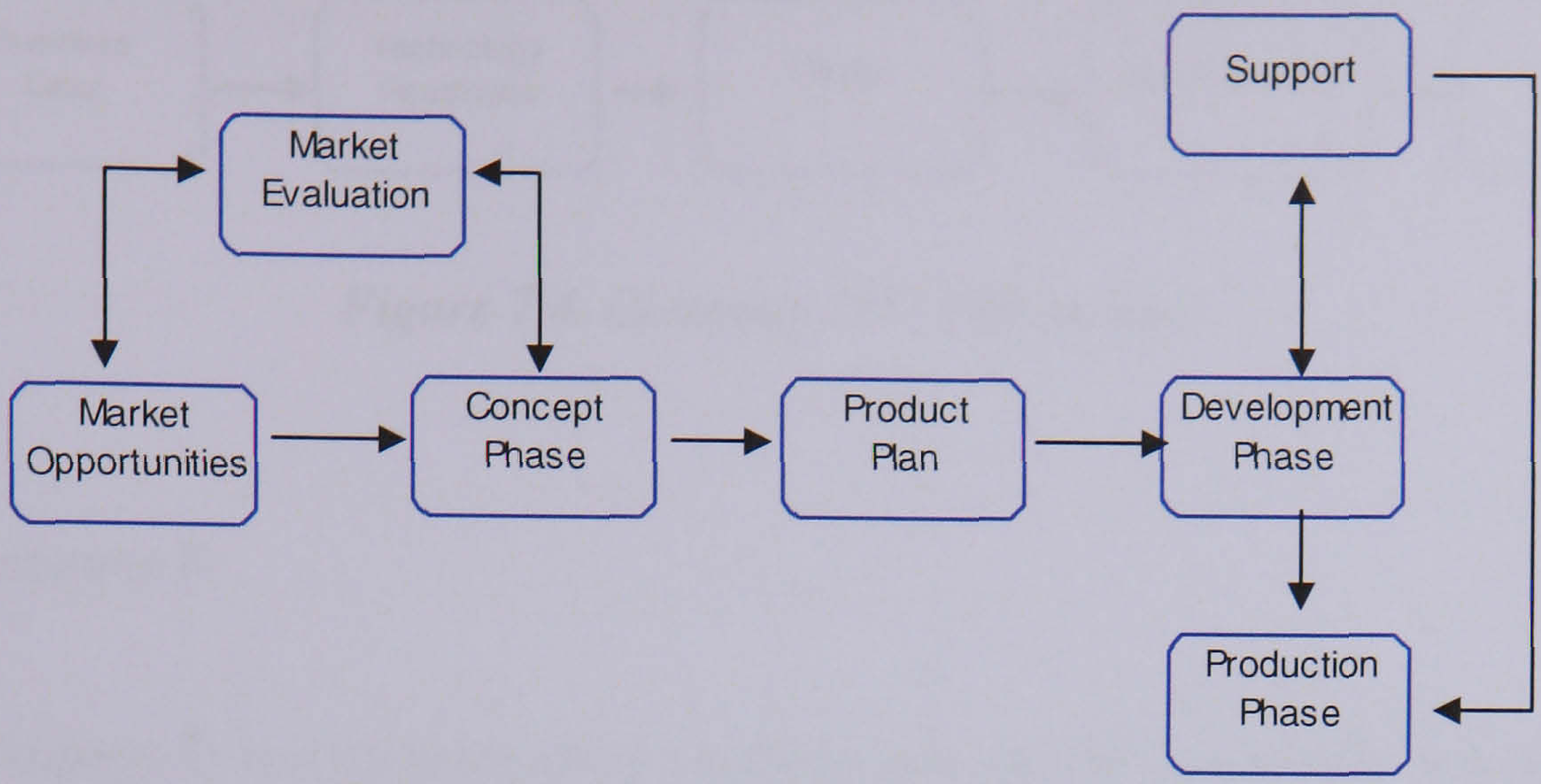

Figure 7.2. *Company "A" NPI Process*

Company B

Company B is an organisation that provides electronics system for the aircraft industry. They have recently undergone a business improvement exercise that also addressed their NPI process. The NPI process defined at the end of this improvement activity is documented below.

Figure 7.3. *Company "B" NPI Process*

Company C

Company C is a large international office solutions provider with headquarters in the US. This company does follow a formal NPI process that forms part of the company's business procedural system. The process consists of 5 distinct stages that are outlined below.

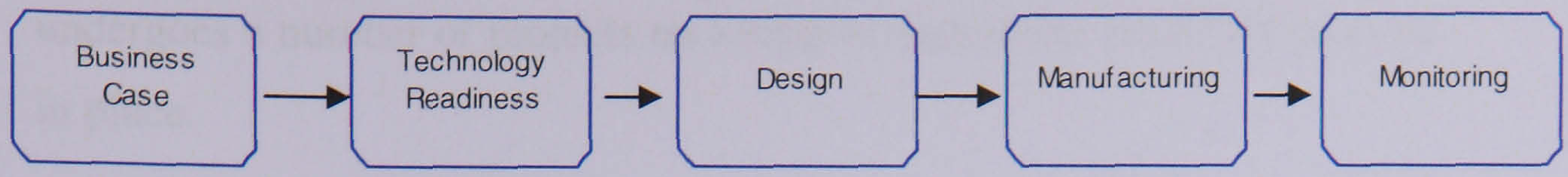

Figure 7.4. Company "C" NPI process

Company D

Company D is a medium sized company that provides electronic test and measurement equipment to its market. It is a world-wide company with headquarters in Japan. This company also follows a documented NPI process of 8 stages shown below.

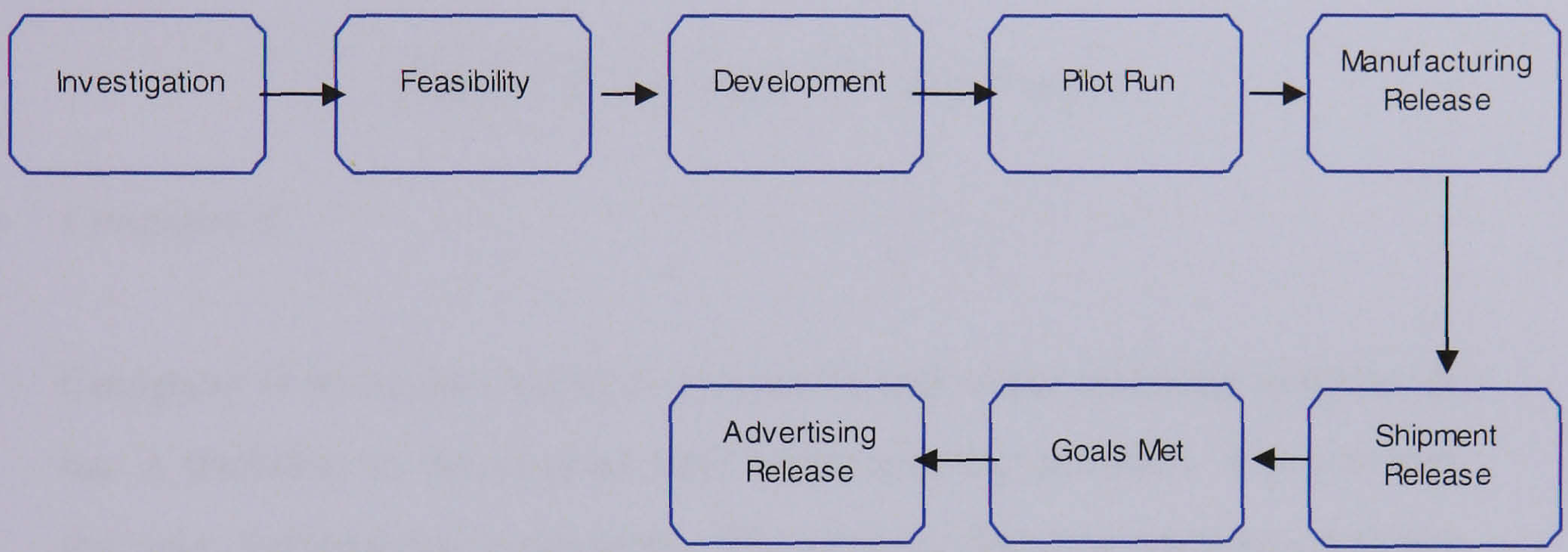

Figure 7.5. Company "D" NPI Process

Company E

Company E is a well-established engineering company member of the Engineering Excellence Programme. A lot of effort is spent on research and development as well as consultancy. However, although the company undergoes a number of projects on a regular basis there is no NPI process in place.

Company F

Company F has a strong reputation for its reliable products. The company also seems to be a standards setter for quality and reliability. This company follows a 6 stage NPI process that is represented below.

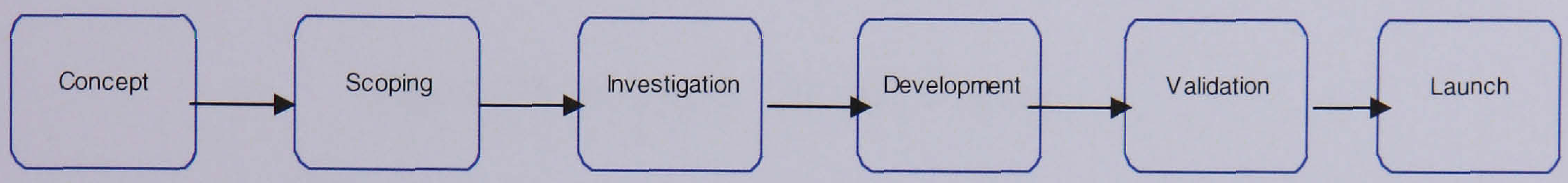

***Figure 7.6**. Company "F" NPI Process*

Company G

Company G is market leader in electricity and water metering systems. It has a tradition in developing and manufacturing products and services that use cutting-edge technology. The process that this company follows is shown in the diagram below.

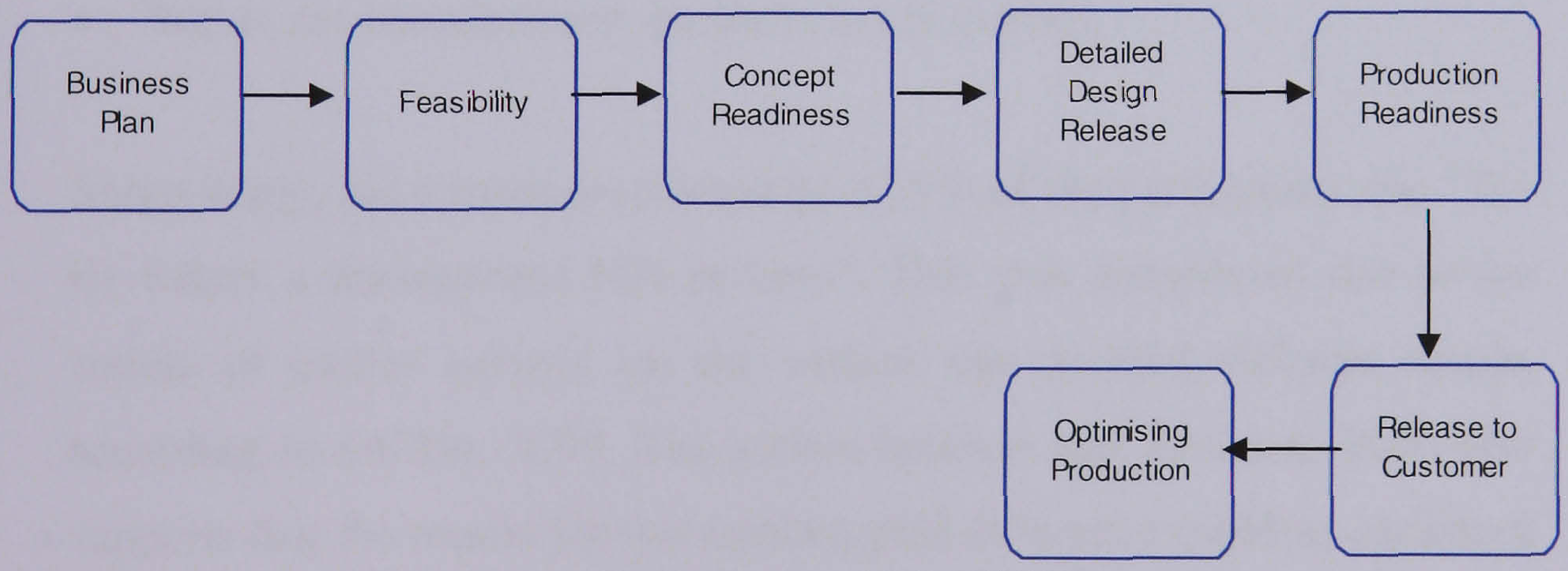

***Figure 7.7**. Company "G" NPI Process*

Company H

Company H is a global company that specialises in the design, supply and support of innovative and advanced instrumentation for a number of industries. The process utilised by this company can be seen in the following flow.

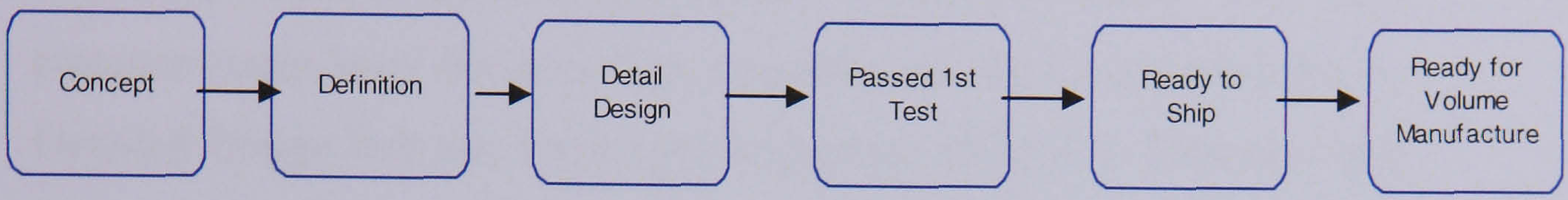

Figure 7.8. *Company "H" NPI Process*

7.3.3 Information related to the NPI process

The following statements were included in the questionnaire related to the status of the company against the NPI process:

- We do not follow a documented NPI process.
- We do follow a documented NPI process.
- We are in the process of developing a NPI process.
- We do not introduce new products to the market.

Surprisingly, the statement selected by 87.5% of the participants was "We do follow a documented NPI process". This was unexpected due to the results of earlier surveys on the subject that yielded different results according to Griffin, 1997. The author believes and Rosenau, 2000 also supports that the reason for this fundamental difference could be attributed to the awareness during the last few years of the focus and importance of processes as well as the significance and relevance of the time-to-market to competitiveness.

From the 87.5% of the companies that do comply with a fully documented NPI process all of them follow a stage gate process that consists of between 5 to 9 stages. This is quite common to all companies after reviewing relevant literature from Jones, (1997) and others. The most common stages were Business Plan, Feasibility Study, Concept Readiness, Detailed Design Release, Production Readiness, Release to Customer and Optimised Production. The duration of each NPI process varies between a few months to more than 2 years in some cases, as seen below on the table 7.1 and the figure 7.9.

Table 7.1. Duration of NPI processes in the different companies

Duration of NPI process	*0 - 6 mon*	*6 - 12 mon*	*1 - 2 years*	*2+ years*
Company A			X	
Company B			X	
Company C				X
Company D				X
Company E		X		
Company F			X	
Company G			X	
Company H		X		

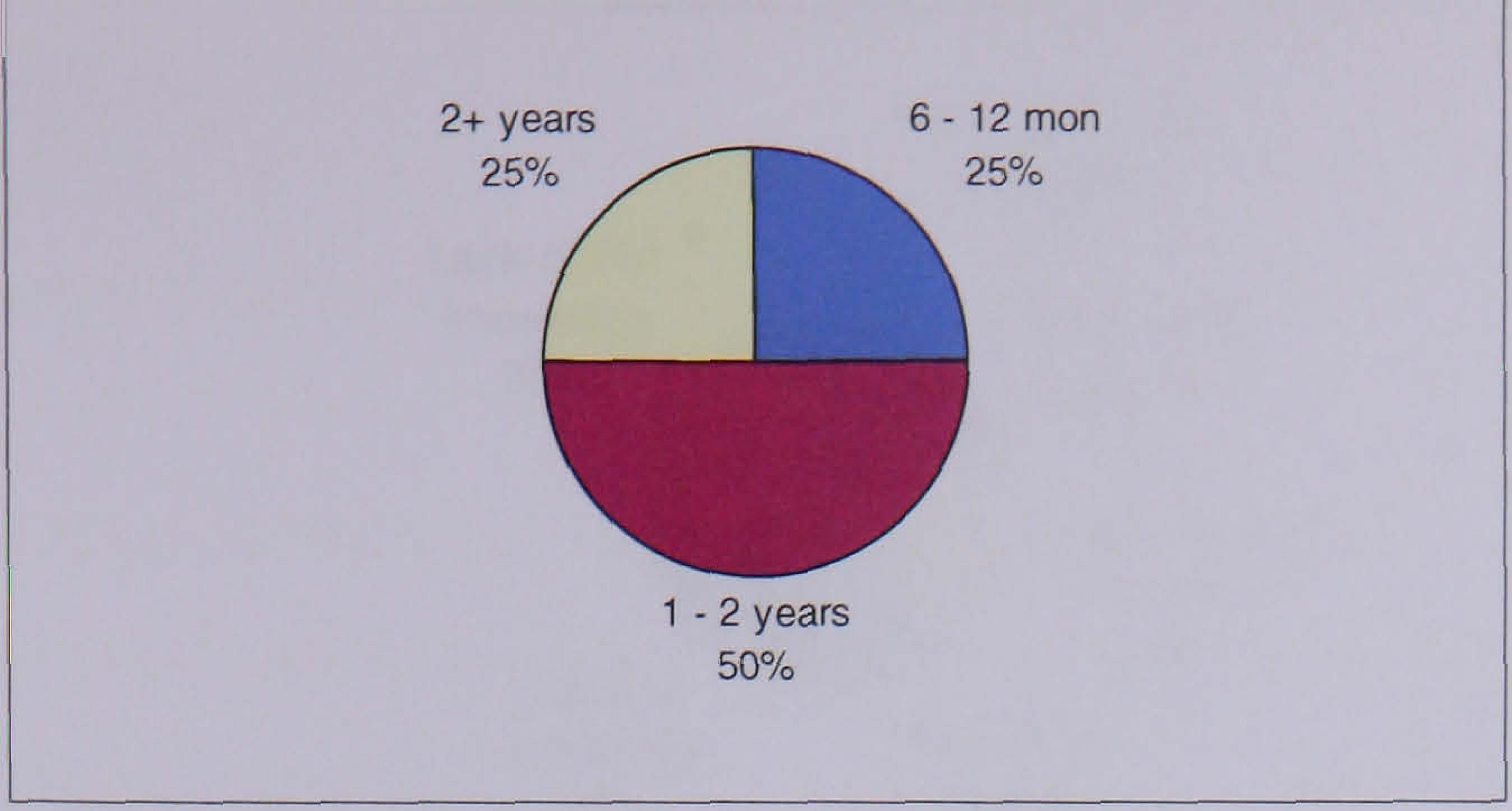

Figure 7.9. *Duration of the NPI process*

However, all companies when asked in the questionnaire admitted shortfalls related to their NPI processes, including:

- lack of an established communication method between the stages of the process;
- lack of a formal process;
- frequent changes in customer requirements;
- production issues usually related to no Design for Manufacture and Assembly;
- lack of continuity in the process;
- knowledge gaps in Project Management techniques;
- cost of technical changes and design improvements;
- accuracy of project plans;
- delays in approval routes and documentation; and
- literature and time to train the sales force in order to promise achievable deliverables.

The following were the most commonly quoted issues related to this process.

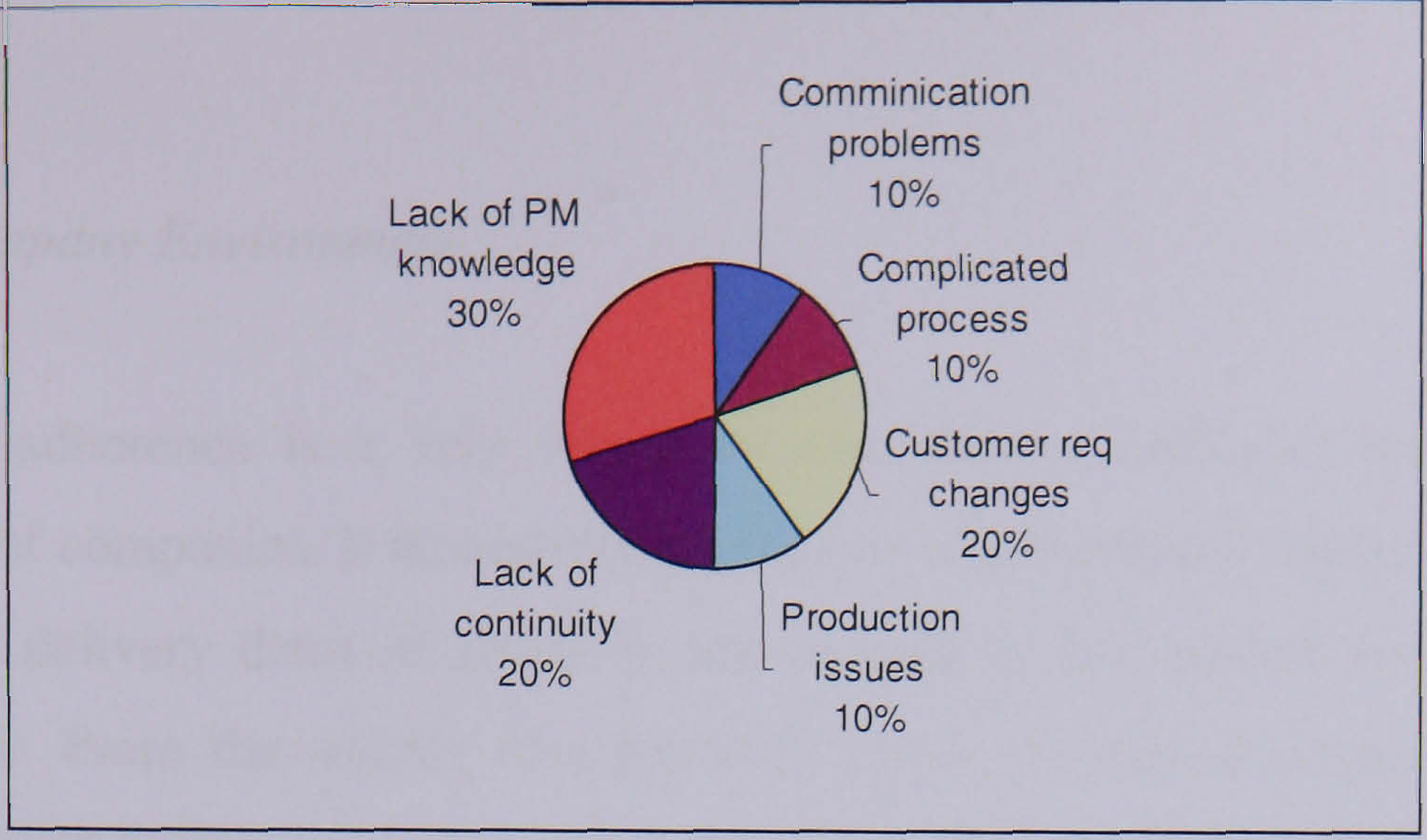

Figure 7.10. Common issues with the NPI process

All of the participating companies also identified delays in the time to market and delivery adherence. The majority (62%) identified delays of approximately 6 months, the remaining companies identified delays of about 3 months and 4 months. These delays represent an average of 30% of the company's duration for a typical NPI project.

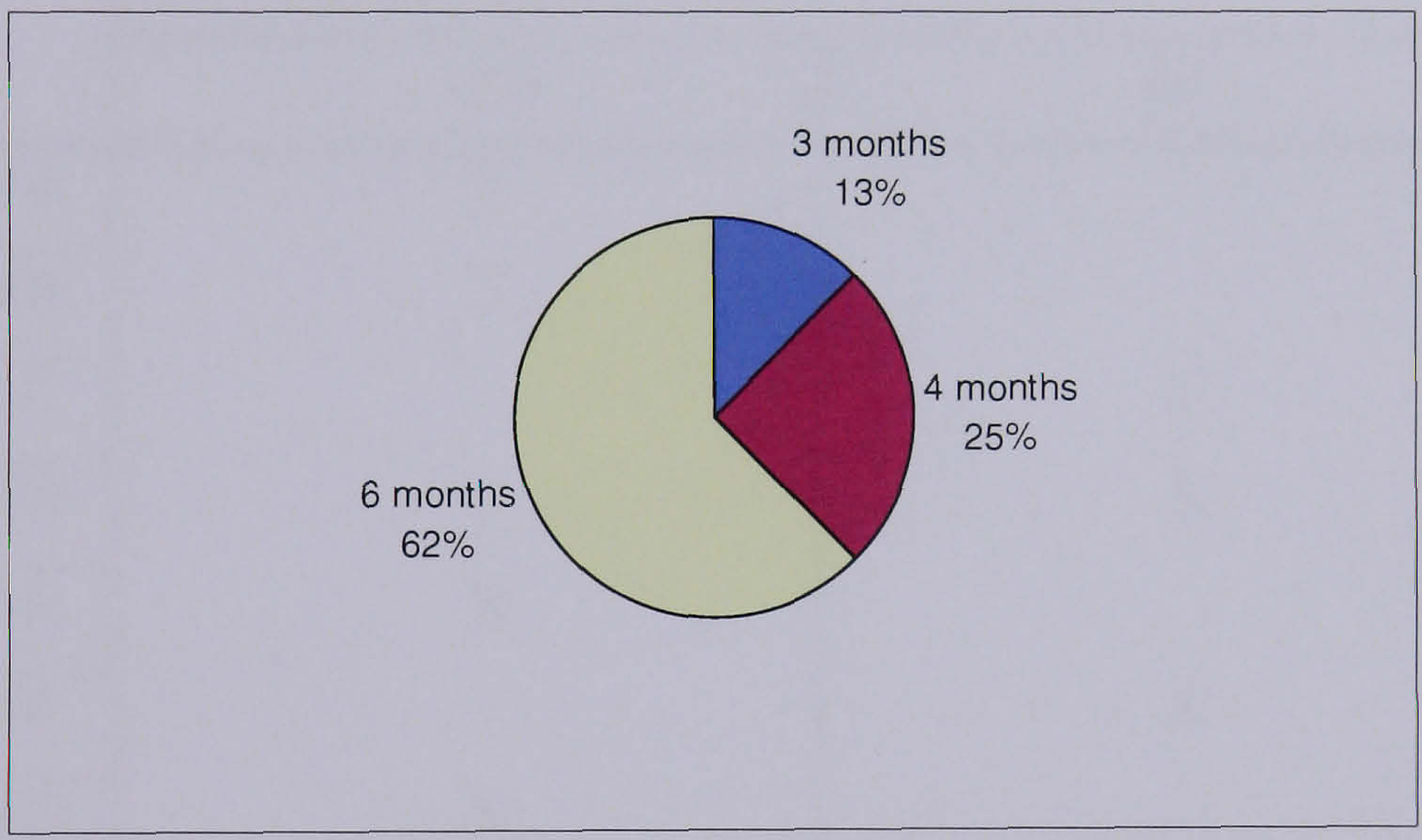

Figure 7.11. Delays in the NPI process

7.3.4 Company Environment

Delivery adherence is a very important performance indicator for the majority of companies. It measures the company's performance against the promised delivery dates of products and services to the market and the customers. From the sample of companies involved various patterns of delivery adherence can be observed. Certain companies have to compensate their customers for late deliveries. This study showed that there is a split between companies on this issue (table 7.2). From those companies that have to offer compensation for lateness all of them have a 1 to 5% penalty on the sales price.

Table 7.2. Compensation to customers for late deliveries

	Does your company have to compensate your customers for late deliveries	
	yes	***no***
Company A	X	
Company B	X	
Company C		X
Company D		X
Company E	X	
Company F		X
Company G	X	
Company H	X	

In certain situations companies might have to review their sales prices if their products will reach the market later than expected. From the analysis of the results it was identified that 12.5% of the companies reduce their sales prices by an average of 5 to 10% (Appendix 6).

7.3.5 Conclusions

The survey results complimented the information gathered from the preliminary interviews and critically assessed the literature in the subjects researched. In contrast with previous surveys the majority of the respondents had a documented NPI process, which verifies the significance of the process and the trend of company's investment in process mapping and continuous improvement.

The majority of respondents also admitted that there were a number of shortfalls with their processes. It was also highlighted that delays throughout the NPI process have an adverse effect upon the company performance and profitability. This is evident since most of the participating companies had to compensate customers for lateness, reduce their sales price to counteract their late entrance to market or in certain cases do both of the above. These measures that companies are forced to take to dampen the effect of entering their market late effect their cost base. The author will use these measures on the following chapter (chapter 8) to formulate a set of indicators that aim to quantify the effect of delays throughout the NPI process.

7.4 Follow up Interviews

The data initially gathered from the questionnaire was reviewed producing the data and graphs presented above. In order to obtain further information as well as to triangulate the information provided follow up structured telephone interviews were organised. The main objective of these interviews was to establish the level of measurement of the NPI process within the respondents' companies and the measures or systems most commonly used.

The author interviewed all of the company representatives and the material gathered (notes, papers) from all the interviews were compared against the objectives (page 101) of this study. The majority of those interviewed were employed in positions of Engineering Management. About 2/3 of those held high positions of authority in their respective companies.

The interviews were conducted to specifically assess the current state of performance measurement within the NPI process. All of the interviews followed a script (Appendix 7) prepared to verify, validate and compliment the data provided by each organisations. Call-backs were also used where information needed to be verified and clarified.

The questions that were asked on these interviews focused on the following, in order to obtain information against the aims and objectives detailed on section 1.2:

- the characteristics of the business that may influence the NPI process.

- the sensitivity of the current NPI process to those company characteristics.

- the company performance measures used to evaluate the performance of the NPI process.

- the need for a specifically designed system to measure the performance of the NPI process.

There was a general agreement that company characteristics do influence the NPI process and that they should be taken into account when the process is defined or reviewed. Characteristics such as company size, culture, technical expertise and competition were mentioned as characteristics that may influence the NPI process. However, none of the interviewees claimed to know the resulting effects of these characteristics in different organisations. This is probably due to the fact that none of the interviewees had delved into this aspect before.

The interviews however, did provide data that agreed with research (Driva et al., 2000) that was carried out in the past regarding the indicators used to measure the performance of the NPI process. The measures mentioned by all participants as being used at some or all NPI projects were:

- On time Delivery.
- Schedule Adherence.
- Project Costs against Budgeted Costs.
- Return on Investment.

These measures were solely used as means to report progress at a weekly, or in some cases monthly, high level management meeting. The data from these measures is not used as a predictive indicator for potential improvement and corrective activity. All the participants agreed that these measures were not very useful and that they did not provide them and their teams with any meaningful data that they could investigate further in order to improve their, and therefore their companies' performance. This concurs with literature in this field and also the author's industrial experience. A new measure specifically developed that takes into account the peculiarities of the NPI process sounded very interesting to all of the interviewees and they all agreed that it could be of tremendous use to them and their companies.

7.4.1 Conclusions

The follow up interviews generated very valuable data, particularly in terms of the research content. The detailed interviews were the last research method to be carried out for this project. This method was quite time consuming but it did generate a significant amount of relevant data since each conversation was steered by the author with a number of open and closed questions.

One of the objectives was to evaluate whether or not a performance measurement system specifically designed for the NPI process would be useful. The interviewees, when asked whether such a method would be of a benefit to their company, appeared to accept the appropriateness of a method that will assist practitioners in defining and measuring their NPI process.

The author in chapter 5 recognised that there are no adequate measures currently in use that can satisfactorily measure the performance of the process. The interviews also support this. This was quite important to this research since it forms the basis of the tasks that followed.

7.5 Overall Conclusions

While the research design determines the validity of the results, there are issues that may effect the applicability of the research. Every effort was made to avoid some of the more common threats to the validity for this kind of research, such as poor methodology and lack of generalisation. Frequent interaction with the research supervisors along with regular reviews of the findings, contributed to ensuring valid research design. The analysis of the data was done using Microsoft Excel (details on page 181). Additional statistical support was provided by Minitab.

The activities carried out for this research generated a mass of data and information relevant to the research questions. This chapter has taken each activity in turn – preliminary interviews, survey, follow up interviews – and presented the observations and conclusions that can be drawn. The individual methods have all contributed to the research process and research content. A strength of the multi-methods approach is that by looking at the same issue from different directions some of the weaknesses inherent in any research method can be mitigated, allowing construction of a more complete and robust picture of the issue under investigation.

The data collected has positively identified the issues listed in chapter 5 as genuine concerns of the organisations reviewed. The results demonstrate that most companies that offer new products or services to their markets engage in a form of NPI process. Different organisations engage in different NPI activities depending on their products, markets and strategic development plans. The duration of the NPI process is measured by the Time-To-Market of a new product/service to the target market. Inevitably, delays do occur throughout the NPI process for all companies, even though some may have a well-documented and managed NPI process. The measures that are predominately used do not provide practitioners with the necessary data required for improvement (Koliza et al, 2004). There is a clear lack of a predictive measurement system that will produce adequate information that will lead to recognisable improvement of the NPI process.

The overall objective of this research project is to provide a methodology of resolving issues related to the NPI process, therefore reducing time-to-market which should enhance business performance. This methodology should provide an adequate measure for the process, providing valuable information that should potentially lead to process and profit improvement. The methodology proposed by the author in the next chapter is intended to define, measure and improve the NPI process by the use of clearly defined steps that will establish the current NPI process status, measure its effectiveness using a set of indicators developed by the author whilst providing an action plan based on a matrix (also developed by the author) that prioritises corrective action based on maximum benefit.

Chapter 8

8. A PERFORMANCE MEASUREMENT METHOD FOR THE NPI PROCESS

8.1 Introduction

As stated in section 1.2, the aim of this thesis is to explore the scope for the application of a performance measurement methodology in the NPI process. Chapters 2 and 3 explained in detail the current state in the fields of NPI and Performance Measurement in general. Chapter 4 described how performance measurement and systems are currently applied to the area of NPI. Chapter 5 provided a summary of the issues identified from the original research and literature review. Chapter 6 reported the multi-method approach used that included preliminary interviews, a postal survey and detailed interviews in eight companies. Chapter 7 explained the findings from the multi-method approach.

This chapter will draw on all these sources to discuss the application of a NPI performance measurement method, developed during this research programme.

In this section the method proposed that has been generated by the author will be described in detail. Each of the 5 steps of the method will de explained and clearly defined. The 5 steps are:

- Step 1 - process mapping activity;
- Step 2 - quantitative analysis;
- Step 3 -problem solving;

- Step 4 - qualitative analysis, using the Soft Systems Methodology; and
- Step 5 - quantification of the improvement achieved.

8.2 The Performance Measurement Method Developed by the Author

This research project has identified a number of shortfalls related to the NPI process and the methods currently used for the measurement of its performance. The NPI process is one of the most significant processes carried out in an organisation and its performance is linked to profitability and growth. The overall target of this research is to provide an appropriate performance measurement indicator that assists in resolving issues therefore reducing the duration (time-to-market) and costs of the NPI process. The methodology proposed comprises 5 steps put together by the author based on the principles of continuous improvement cycles (Deming Cycle).

In order to start this activity a good understanding of the current practices should be in place. Although the majority of the survey respondents stated that they followed a documented NPI process (Koliza et al, 2005) it is very important to verify that the documented process reflects the actual practice. For those companies that do not have a documented process it is imperative to sketch out the steps followed. The first step in the proposed method is to analyse the current situation by graphically representing the NPI process with the assistance of a Process Map (section 8.3). This mapping exercise should also include the identification of wasteful and non-value adding activities that have been incorporated in the current process and procedures through the years.

The second step is to apply a quantitative model, shown in the relevant section (8.4), to financially quantify the effect of the identified delays. To benchmark the current situation a value indicator can be used to evaluate the losses caused by these delays in relation to the sales turnover. This indicator can then be used as an original point of reference that can be used to report subsequent incremental or total improvement. The indicators used here were developed, based on literature and industrial experience of the author, throughout the duration of this project. They have been specifically designed to incorporate the peculiarities and unique characteristics of the NPI process. These indicators provide a direct link between the process, its delays and consequently the overall company profitability.

The third step is to prioritise the delays according to their value indicators (section 8.5). At this stage problem-solving techniques can be used to identify ways to resolve the issues identified in the previous step. A number of techniques could be put into action according to the knowledge and experience of those involved. A relatively uncommon problem solving technique in the industry is the Soft System Methodology (SSM) developed by Checkland in the 1960s. SSM is proposed as a method that can assist in the mapping of fuzzy processes. This method integrates a number of techniques such as cause and effect and brainstorming that when used together should yield enhanced clarity.

The fourth step is to use a matrix to place the delays according to their scope (long term, short term) and effort (easy, hard) required for their resolution. According to this qualitative analysis, the issues identified can form the basis of an action plan based on the significance and the urgency of each delay.

The fifth step is to quantify the savings achieved through the improvement process. If the delay is completely eliminated then the value indicator for the losses incurred will automatically show the value of the sales turnover that can be realised. If the delay is substantially reduced in time the quantitative model and the value indicator can be reused and compared with the original figure, thus showing the improvement.

In line with the continuous improvement culture this method can be reapplied to create a new action plan for further progress. Applying this methodology will assist practitioners in dividing the overall problem into manageable tasks. It will provide scope for the improvement project as well as quantifying not only the issue in hand but also the progress made.

8.3 Step 1: Process Mapping Activity

There are several "mapping" techniques, which follow the route of material, customers or information flow. According to Rother et al (1999), a value stream map indicates all the actions (both value added and non-value added) currently required to bring a product or service to market realisation, through the main flows essential to every product. In essence most mapping techniques are similar to process charts or maps used at a more macro level for analysis. The types of activity that will be considered value adding depend on whether or not the customer is willing to accept their cost. The activities classed as non-value adding are those that have to be carried out under current circumstances and should be simplified, merged or eliminated in order to shorten throughput times without detracting from the value adding activities.

Process maps are a simple means of recording the details of work for subsequent analysis. As Stalk (1999) mentions regarding process maps that, "*they are in common use by a lot of practitioners, they are also seen as a common "language" which facilitates analysis*".

Once a company has already gone through the exercise of documenting their NPI process, valuable information can be gained by following an actual product throughout its development stages in order to compare the documented mainstream process and reality. The outcome of this activity often reveals that corners are cut and steps are skipped, such as documentation and analysis, when necessary to counterpoint delays and variances that occur during the product life cycle. It is obvious that Time-to-Market and shortening the lead times where possible is of an essence when introducing a new product. However, the balance between risk and timeliness should be assessed. At this stage any measures that are used or could be used to assess the performance of the process can be incorporated to the process documentation so that they are institutionalised rather than an ad-hoc activity.

The process mapping technique could also identify the variety of IT tools and software used throughout the process. Microsoft Word and Excel are widely used as aids for information storage and progress reporting. CAD programmes are used for the design and development of products, and Microsoft Project for project planning and reporting. Business Information Systems (i.e. Enterprise Resource Planning (ERP) Systems) are only used for production operations. All of these databases are not integrated very often making the sharing and usage of information a laborious task. This makes the process of NPI more complicated due to poor data exchange and information isolation.

After the NPI process maps are thoroughly reviewed, potential delays can be identified. Any of these delays can potentially extend the time to market, with known effects to a company's performance. Therefore, it is important for such delays to be eliminated or substantially reduced. However, it is not always easy to resolve NPI related issues, due to the complexity of activities and the involvement of several different functions throughout the process. In a lot of cases the issues are interlinked and it is very difficult to identify which of them need to be addressed first to maximise the benefit from its resolution. Step 2 provides a value indicator that assists in quantifying the effect of the delays, overall or individual, in terms of company losses.

8.4 Step 2: Quantitative Analysis

By reviewing the delays identified during step 1 it is possible to estimate those delays that have the biggest effect on the Time-to-Market (TTM). However, the contribution of these delays to the TTM is not obvious, it is even more difficult to estimate when delays are not recorded. An indicator to assist this matter could be extremely useful in prioritising the contributing delay factors. A measure is therefore needed to assist in prioritising the delays identified so that actions can be taken to reduce or even eliminate them.

There is however the question of what needs to be included in such a measure and what the variables should be for the performance indicator defined to produce valid results. Pattikawa et al (2006) suggest that there are a number of ways that the performance of new product project can be assessed. Some of these factors are:

- Degree of organisational interaction.
- R&D and marketing interface.
- General product development proficiency.
- Product advantage.
- Financial/business analysis.
- Technical proficiency.
- Management skill.
- Market orientation.

- Technology synergy.
- Project manager competency.
- Launch activities.

By reviewing the nature of these factors it can be seen that the majority of them are very difficult to quantify and relate to business performance measures such as profitability. The author reviewed the available literature, the input of the NPI practitioners and used the experience gained of working with a number of different NPI processes to identify the measures that could be quantified. The result of this research was that actual and potential costs caused by the delays in the process could be used to provide an indicator of the performance of the NPI process.

A financial calculation of the actual and potential costs caused by these delays can prove a valuable aid in this process. Taking this a step further, it is also possible to identify the impact of a particular delay to bottom line profitability.

In order to calculate the actual and potential costs of a delay, the impact of this delay to the business needs to be identified. The activity that is considered a delay could be an inefficiency in the process, otherwise known as a "waste", or it could be a "non-value-adding" activity that has to be followed under the current circumstances, or otherwise a constraint. In both cases this activity carries a cost, if the attendance of a resource is necessary. This is an actual cost since the resource could be more efficiently utilised completing a "value adding" activity.

Additionally, companies may be required to compensate their customers for delayed deliveries of services or products. These penalties, in certain industries known as liquidation damages, often represent a percentage of the order value. A percentage of these penalties also forms part of the actual cost that can be attributed to the delay(s).

Finally, potential costs can be identified due to lost opportunity and sales price reductions. Customers are often turned away due to the length of the time-to-market. In certain industries these customers will never return thereby reducing the market share of the organisation in the specific market. To compensate this certain companies resort to reducing their sales price to make sure that they secure a section of the available market.

The development of the method proposed is explained in the subsections that follow. In chapter 10 there is an illustration of its use on a case study in Company A.

8.4.1 Actual Cost of the Delay

Every activity that forms part of a process carries with it a cost. This cost is due to the resources utilised carrying out this activity throughout its duration. This in activity-based costing is represented by the term direct cost (Kaplan et al, (1987). In order to calculate the actual cost, the *duration of the delay* in hours *(D)* needs to be identified. Process modelling as well as value stream mapping can assist in identifying the delays as well as estimating their duration. In order to calculate the actual cost of the delay itself, D needs to be multiplied by the average *internal hourly rate* (I_{hr}). If a specific resource is used to undertake this task then the specific hourly rate (I_{shr}) could be used for a more accurate calculation. Therefore:

Actual Cost (C_A) based on a single delay and average hourly rate:

$$C_A = D \times I_{hr} \qquad \text{(equation 1)}$$

Or

Actual Cost (C_{AS}) based on a single delay and specific hourly rate:

$$C_{AS} = D \times I_{shr} \quad \text{(equation 2)}$$

To identify the Total Cost for *all the delays* based on average cost, that occur in the process or throughout the year then:

$$\sum C_A = D_1 \times I_{hr1} + D_2 \times I_{hr2} + \ldots D_n \times I_{hrn} \qquad \text{(equation 3)}$$

where:

n = number of delays

8.4.2 Actual Cost due to Penalties (Liquidation Damages) in the Customer Contract

Penalty clauses are often found in contracts involving development work of new products and services (Brizzee, 1991). In these clauses an amount is agreed to be paid to the customer in the event of a late delivery. Most companies are required to compensate their customers for delayed deliveries of services or products. However, not all orders are covered by this clause. If penalties or liquidation damages apply then a percentage of the amount paid can be attributed to the delay(s) in the NPI process.

To calculate this figure we need to use the *Order Value* (O_V). However, for simplification and expediency it is recommended that the *Average Order Value (Aov)* is used. The Average Order Value can be calculated as follows:

- Identify the total *quantity of customer orders per year* (Q_{CO})

- Divide the *Sales Turnover for the year (T)* by the customer orders to calculate the *Average Order Value*

$$Aov = T / Q_{CO} \quad \text{(equation 4)}$$

The next step is to identify *the number of orders that have penalties or liquidation damages clause in their contract (Q_C)*. This information should be readily available from the company's financial data.

The *number of customer orders for which penalties are paid this year or are expected to be paid (Q_C)* needs to be considered.

Usually, the total *liquidation damages or penalties (P_i)*, are a *percentage (Pc_i)* of the actual customer order value therefore:

$$P_i = (Ov_1 \; x \; P_{C1} + Ov_2 \; x \; P_{C2} + \ldots\ldots \; Ov_n \; x \; P_{Cn}) / 100 \quad \text{(equation 5)}$$

If an *average order value (A_{ov})*, and an *average percentage of penalties (P_c)* is to be used then the *total average liquidation damages or penalties (P)* would be:

$$P = (Q_c \; x \; A_{ov} \; x \; P_c) / 100 \quad \text{(equation 6)}$$

However, not all of this value can be attributed to the delay(s) in question. In order to identify the potential attributed cost due to the particular delay then the contribution of this delay to the overall time-to-market needs to be identified. In order to do this the following needs to be calculated:

- Identify average value of *time-to-market* (T_h) in hours based on similar product requirements;

- Using the already identified value D *(delay in hours)* calculate the *contribution (C) of the delay to the overall time-to-market* as:

$$C = (D / T_h) \times 100 \qquad \text{(equation 7)}$$

If a total delay figure needs to be used then the above equation will be:

$$C = (\sum D / T_h) \times 100 \qquad \text{(equation 8)}$$

This means that the *Liquidation Damages or Penalties* (P_{LD}) this year attributed to the delay are:

$$\boxed{P_{LD} = P \times C} \qquad \text{(equation 9)}$$

This calculation will be sufficient for companies that have limited product variety. This means that all products have very similar characteristics when it comes to their development requirements and they are covered by fairly identical processes. In the case of a company with a diversity of products the above calculations will become more meaningful. Values such as the Average Order Value, the Sales Turnover, and the Liquidation Damages or Penalties could be calculated by product family providing specific data for the product family in question. This may lead in the NPI process actually being slightly different for the different product ranges/families that the company is introducing into the market.

8.4.3 Potential Costs

Delays in the process, apart from actual costs, can also lead to potential loss of customer orders and market share, as well as loss of resources that could have added to a different project. According to Collins and Hull (2002) opportunity costs of being late to market are often enormous, therefore they should be included in such a model. Being a late entrant to the market also reduces the pricing advantage of introducing a product or a service first to the market. Thus, a number of companies are reducing their sales price in order to compensate the market loss from the "faster first".

To identify the potential costs due to lost order caused by long time-to-market the method below needs to be followed:

The quantity of *lost orders* (C_{LO}) in value due to the delay is required in order to calculate this potential cost. If this information is not readily available it can be calculated by following the analysis described below:

- Identify the *number of quotations* that are received each year (Q_q)

- Identify the *number of quotations that have been successful* and converted to a customer order (Q_{sq})

- Calculate the orders lost: $Qq - Q_{sq}$

- In order to convert this into a monetary value the *Average Order Value (Aov)* needs to be multiplied by the above calculation:

$$C_{LO} = (Q_q - Q_{sq}) \times Aov \qquad \text{(equation 10)}$$

However, not all the lost orders can be attributed to the long lead times or time-to-market, factors such as quality and service may lead to order loss. Therefore, a percentage needs to be identified to reflect the number of quotations that were not realised as orders due to extended time-to-market. If this information cannot be retrieved from real data, then an estimated *percentage (TTM)* would have to be used for this calculation, based on past performance and experience.

Then the potential order loss due to long time-to-market (C_{ttm}) can be represented as:

$$C_{ttm} = (C_{LO} \times TTM) / 100 \qquad \text{(equation 11)}$$

As above (equation 7 and 8), the contribution of the delay to the total time-to-market can be identified by the use of the C factor.

Finally, to calculate the Potential Attributed Cost of the Delay due to loss of Customer Orders or *Opportunity Cost* (C_o) the following formula needs to be used:

$$C_o = C_{ttm} \times C \qquad \text{(equation 12)}$$

To identify the potential costs due to loss of pricing advantage the method below needs to be followed:

The *Desired Sales Price* value (D_P) in pounds needs to be identified at this stage and compared with the *Actual Sales Price* (A_P) that could be derived as a factor (*f*) of the Desired Sales Price.

$$A_P = f \times D_P \qquad \text{(equation 13)}$$

The *Potential Pricing Advantage* per unit *(PPA)* can then be calculated as:

$$PPA = D_P - A_P \qquad \text{(equation 14)}$$

Finally, the *Potential Pricing Advantage Loss* *(PPA_L)* due to the Delay can be represented as:

$$PPA_L = C \times PPA \times Q \qquad \text{(equation 15)}$$

where

Q = quantity of units sold a year

C = the contribution of the delay to the time-to-market

The total of the *Potential Costs (PC)* is therefore calculated by the following:

$$\boxed{PC = C_O + PPA_L} \qquad \text{(equation 16)}$$

The same comment made at the end of section 8.4.2, regarding product families applies to this section as well. More meaningful figures will be calculated if the values are based on product family averages rather than averages derived by data covering all products.

8.4.4 Summary

The summary of results from the above calculations are:

Actual Cost Attributed to the Delay (AC_D):

$$AC_D = \sum A + P_{LD} \qquad \text{(equation 17)}$$

Potential Cost Attributed to the Delay (PC):

$$PC = C_O + PPA_L \qquad \text{(equation 18)}$$

To identify these losses (L) as a percentage of the Sales Turnover (T) the following calculation can be performed:

$$\boxed{L = [(AC_D + PC) / T]\ \%} \qquad \text{(equation 19)}$$

If these losses can be reduced or eliminated, then an equal amount of increase to the profitability should be realised.

The total costs attributed to the delays in the NPI process can then be established by adding the Actual and the Potential costs together. These losses can also be represented as a percentage of the Sales Turnover demonstrating their impact on the company performance. If these losses could be reduced or eliminated, then an equal increase in the profitability should be realised (Koliza et al, 2003).

The effect of the delay on business profitability will depend on whether or not the delay occurs on the critical path of the process. If the delay is not on the critical path then only the actual cost of the resource will have a value, thus minimising the significance of the delay on the sales turnover. However, if the delay occurs on the critical path or it influences the critical path, then its significance dramatically increases along with its contribution to the losses realised. In both cases the criticality of the delay being the chance that the task will affect the project completion time should be reviewed against its cruciality taking into account the extent of the effect.

The values of Actual and Potential Costs Attributed to the Delay will give a good measure of the impact of the delay in question in terms of actual and potential losses that occur throughout the NPI process. This measure can assist in prioritising these delays so that an adequate plan can be produced for their reduction, or were possible, elimination. The percentage of Losses (L) itself is a very valuable indicator of the impact of the delay to the business. A high value of L could mean that a company might never recover, or that immediate action needs to be taken so that the particular delay(s) does not appear in the future.

However, not all of the attributes calculated on the value indicator will influence every company. The different company characteristics would indicate which variables apply. The following table (Table 8.1) shows the applicability of each variable.

Table 8.1. Applicability of the variables identified

Variables	Every Company	Company Characteristic Specific
1. Actual Cost of Delay	X	
2. Penalties		X
3. Opportunity Loss	X	
4. Pricing Advantage Loss		X

8.5 Step 3: Problem Solving

This step uses the issues identified from the process mapping exercise and attempts to resolve them by either reducing their effect or wherever possible eliminating them. There are a number of problem solving techniques that can be utilised here.

Some of the techniques that can be found in the literature are:

- Brainstorming – a creative technique of generating ideas to solve a problem.

- Appreciation – a useful technique for extracting information from facts.

- Drill Down – breaks large, seemingly unmanageable problems to achievable parts.

- Cause & Effect Diagrams – are very useful for making sure that all factors relating to the problem have been considered.

- Systems Diagrams – a powerful tool for showing how factors interact in complex scenarios.

A method that has not been greatly utilised so far and definitely is not referenced as a technique for NPI nature problems is the Soft Systems Methodology (SSM) developed by Peter Checkland. This technique was successfully used to resolve an issue that was identified in the case study that will be described in the following chapter (chapter 9) with great success (Koliza et al, 2003). This was the first published application of SSM in the NPI process.

8.5.1 Introduction to SSM

Peter Checkland developed the soft systems methodology in the 1960s at Lancaster University. This methodology arose out of attempts to apply systems engineering principles ("hard" systems theory) to business problems. Systems engineering emphasises measurable system objectives and the top down decomposition of systems into subsystems.

The soft system methodology (SSM), in its simplest form, can be described as an iterative methodology that focuses and accommodates various stakeholders' perspective in the design of change. SSM learns about the environment and introduces its change programme by improving the problem situation. Conventional usage of SSM and its varieties can be studied from the literature (Checkland, 1988; Checkland and Scholes, 1990; Kartowisastro and Kijima, 1994; Wilson, 1984).

In brief, SSM deals with problem formulation at the strategic level. It partly aims to structure previously unstructured situations, rather than to solve well-constructed problems. It deals with "fuzzy" problem situations - situations where people are viewed not as passive objects, but as active subjects, where objectives are unclear or where multiple objectives may exist (Rosenhead, 1989).

The Checkland methodology (Checkland, 1981), or the seven-stage model is considered by most people to be *the* SSM. However, SSM covers a range of methodologies developed to deal with different situations. A brief overview of the seven-stage model is described in the following pages.

The Checkland Methodology

The seven stages are:

1. The problem situation unstructured (finding out about the problem situation, basic research into the problem area);

2. The problem situation expressed (expressing the problem situation through "rich pictures", more knowledge can be communicated visually);

3. Root definitions of relevant systems (selecting how to view the situation and producing root definitions, from what different perspectives can we look at this problem situation);

4. Deriving conceptual models (building conceptual models of what the system must do for each root definition);

5. Comparing conceptual models with the "real world" (comparison of the results from steps 2 and 4 and identification of differences and similarities);

6. Defining feasible, desirable changes (ways of improving the current situation);

7. Taking action (recommendations for taking action to improve the problem situation).

Stages 1, 2, 5, 6, and 7 can be regarded as working in the real world, while stages 3, 4 can be considered to be systems thinking about the real world.

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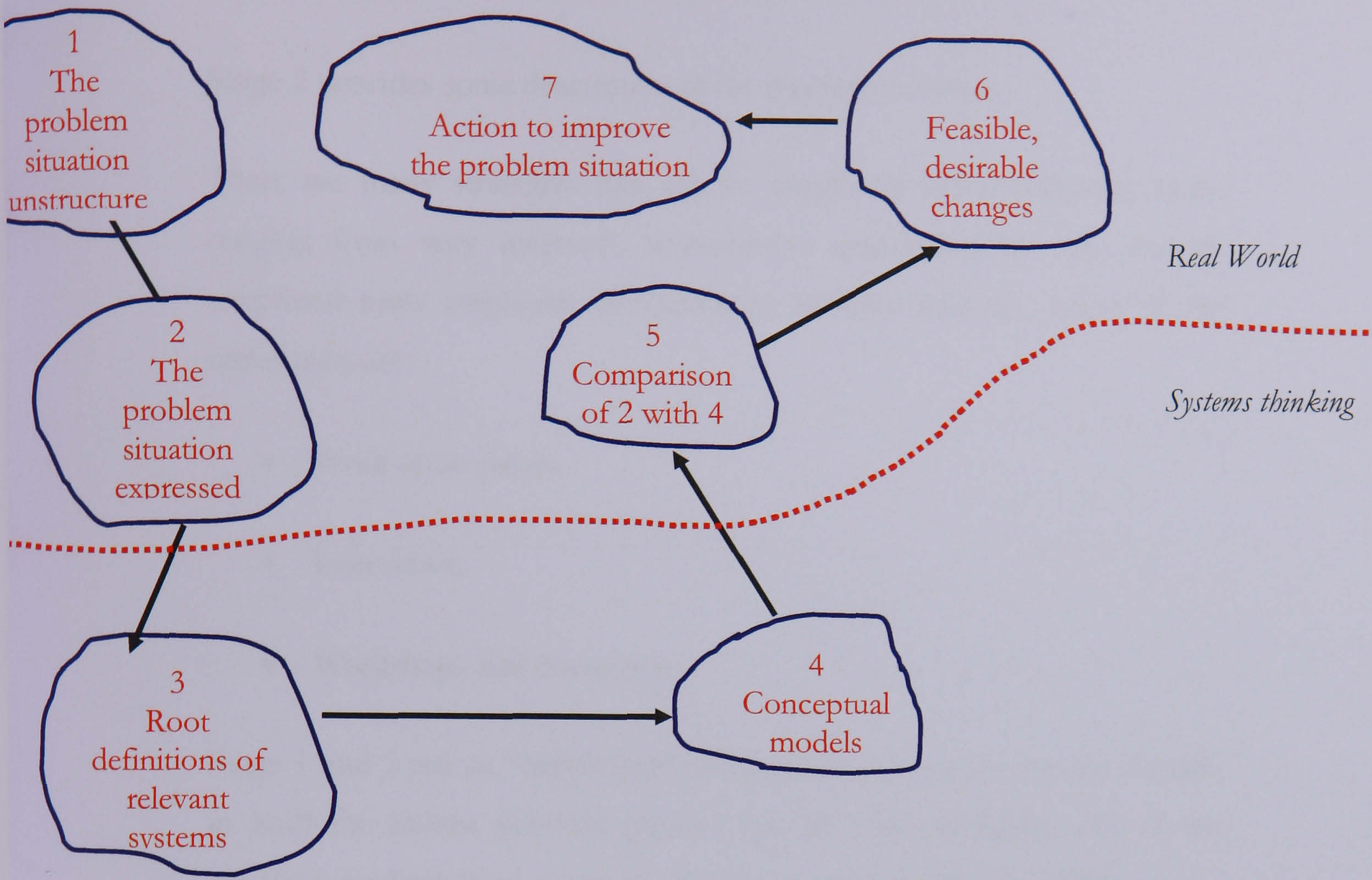

Figure 8.1. *Soft Systems Methodology map*

Stage 1: Problem situation unstructured

The initial stage consists of deciding that a process requires review or change. There might be a problem or room for improvement that initiates the analysis or review. Soft system methodology thinks the term "the problem" as inappropriate because it might narrow the view of the situation. SSM believes that "the problem situation" is more appropriate since there might be many problems, which are perceived to be in need of solution.

Stage 2: Problem Expression

Stage 2 provides some description of the problem situation.

There are many strategies that can be employed when collecting facts, ranging from very informal, unstructured approaches to very formal, structured tools employed in traditional systems analysis. Some of the techniques are:

- Work observation;
- Interviews;
- Workshops and discussion.

Stage 1 and 2 are an "expression" phase during which an attempt is made to built the richest possible picture, not of "the problem" but of the situation in which there is perceived to be a problem (Wilson, 1984).

Rich Pictures

The problem situation can be expressed as a "rich picture". The idea is to represent pictorially all the relevant information and relationships. The rich picture is a way of consolidating understanding of the problem situation. This reduces the possibility of opposing perceptions of the real world hindering the modelling process later on.

Rich pictures are used to provide a model for thinking about the system and to help to gain an appreciation of the problem situation. It is important to note the difference between rich picture and formal models. The rich picture does not attempt to model the system in any precise way. Rich Pictures should represent structure, processes, and issues of the process, which could be relevant to the problem definition. It provides a representation of how a system can be looked at and thought about and it does aid in the refinement of the system. Rich pictures are artistic and individualistic expressions, and therefore not "right" or "wrong".

Stage 3: Root Definition

It is necessary to pay close attention to the formulation of names of relevant systems, and to write in such a way that a model can be built based on these names. These names are known as Root Definitions. The purpose of the root definition is to express the core purpose of some purposeful activity system (Checkland, Scholes, 1990). It is important that attention is paid to the development of root definitions. Properly written root definitions provide a much simpler insight into building system models.

A root definition is expressed as a transformation process that takes some entity as input, changes or transforms that entity, and produces a new form of the entity as output.

"Root definitions" are constructed for the relevant system identified in stages 1 and 2. The root definition should encompass the emergent properties of the system in question. To define the emergent properties one needs to consider the mnemonic CATWOE:

CATWOE Analysis of Stakeholders

Part of the problem expression is working out who are the involved parties. Checkland uses the mnemonic CATWOE to describe the human activity and its situation.

- C: customer (people affected by the system, beneficiaries or victims);
- A: actor (people participating in the system);
- T: transformation (the core of the root definition - the transformation carried out by the system);
- W: *Weltanschauung* (German word which roughly translates to "world view");
- O: ownership (the persons with the authority to decide on the future of the system);
- E: environment (the wider system)

The CATWOE mnemonic can be used as a checklist to ensure that the root definition is complete. Alternatively, the root definition can be formulated from the components of the CATWOE mnemonic. Either way, the root definition will be a short paragraph that will contain all the necessary information to describe the system.

Stage 4: Conceptual Model

Each root definition will result in a conceptual model. The conceptual model identifies the minimum necessary activities for that system. In addition, it represents the relationships between the activities. The conceptual model must be derived from the root definition alone. It is an intellectual model and must not be clouded by knowledge of the "real" world. All of the elements of the CATWOE mnemonic must be included somewhere in the conceptual model; otherwise the conceptual model is incomplete. It should not be possible to take out words from the root definition without affecting the conceptual model.

Checkland suggests as criteria for evaluating a conceptual model the three Es: efficacy (will it work at all), efficiency (will it work with minimum resources) and effectiveness (does it contribute to the enterprise). However, these three Es are not the only metrics that can be used. Other metrics could be used including economical (will it product cost savings), ethical (does it meet the ethical rules), elegant (does it improve the visual effect), and others, which may be dependent on the context of the work being done.

Stage 5 and 6: Comparison - Agree on Changes

The conceptual model is used for comparison with the current system. The conceptual model is meant to provide inspiration, not criticism. It identifies which activities need to be included in that particular system. It is not concerned with how these activities will be carried out. The conceptual model will be compared with the real world to highlight possible changes in the real world. It may be that activities in the conceptual model do not exist in the real world. This will then be a recommendation for change.

Assuming the current situation is not perfect (which is why the study was undertaken in the first place) the enterprise needs to agree on desirable changes. Presumably these changes will move towards the ideal system. At this stage there is a need to go back and draw on the knowledge gained during the problem expression stage, particularly in understanding how proposed changes might affect and be affected by the stakeholders. Changes, which are not agreed on, will not happen.

Stage 7: Action

Finally, the agreed changes need to be implemented. But even here the outcome is not predictable. Checkland sees implementation as a new human activity, so the whole SSM process can start over again. It is unlikely that the final outcome will match the agreed change exactly. During implementation new compromises will need to be crafted.

The question might rise as to how a SSM project will ever finish. In one sense it is not meant to – SSM has a philosophy of continual improvement. But in another sense convergence is hoped for. Some of the issues agreed in the early stages will not resurface, the discussions arising during implementation will be more focussed as the participants' skills in SSM and understanding of the enterprise increase.

8.5.3 Use of the Tool

Peter Checkland states in his book "Systems Thinking, Systems Practice", "The complexity of the universe is beyond expression in any possible notation". Soft Systems Methodology is an attempt to apply science to human activity systems. By the very nature of these systems, Checkland admits that any methodology will be inadequate, but that doesn't mean that it's useless. By examining the Human Activity systems in this manner, vital knowledge about interaction and perception can be drawn. This knowledge will help in understanding and improving these systems.

SSM in general is an iterative approach to problem solving. According to Checkland (1981), the methodology has been refined over a number of different applications. This is due to the nature of the types of problem situations it is meant to deal with which are ill structured and poorly defined. The main advantage of the methodology is that it gives structure to these types of problem situation, which can allow them to be dealt with in an organised manner. It forces the developer to look for a solution that is more than technical.

Soft systems methodology has many critics, both positive and negative.

Technically oriented critics complain that SSM doesn't actually tell you how to build a system, that there is no real method. A possible reply is that there are plenty of technology based methodologies which don't work - what is needed is a way of securing commitment and taking into account a variety of interests. Management oriented critics worry that the open ended nature of SSM makes it impossible to manage - Checkland himself has said that there is no way of telling whether a SSM project is a success or a failure. The same criticism applies to any prototyping or evolutionary approach - perhaps traditional ideas of project management just don't work for organisation change.

SSM has been used in a variety of organisations ranging from a company dealing with food products to British Airways. It has been used to assist in a range of problem situations, such as deriving recommendations for improvement, reorganisation and role analysis. Given the flexibility of the methodology, it can be seen that the range of situations to which SSM can be applied is vast. However, limitations of SSM are the capability, and adaptability to new situations (Platt, Warwick, 1995).

Several people are currently conducting research into ways of overcoming the problems inherent with SSM. There is an ongoing research dealing with the enhancement of SSM through Formal Methods and Risk Analysis techniques. A more practical approach is to use SSM to generate HARD questions that can be dealt with by the more traditional HARD methodologies (Couprie et.al., 1997).

The author's experience of the use of this problem solving method in the scenario analysed was that this method definitely assisted in the process of defining the problem under review. Following through the steps of this methodology, knowledge was gained that enhanced the understanding of the current situation. This also provided certain ideas that were filtered through and were incorporated on the conceptual model.

Other NPI issues that have been identified share the same or very similar properties as to the one that was investigated. Since SSM proved to be very useful in simplifying this problem it can be utilised and potentially assist in the resolution of problems of similar nature.

8.6 Step 4: Qualitative Analysis

Problem solving is a very challenging and time consuming activity, particularly when dealing with complex and ill-defined problems and issues. The analysis that needs to take place in order to structure and simplify such issues has two aspects, which are in essence quantitative and qualitative in nature. Part of the quantitative analysis is to collate and then concentrate on the facts, largely in the form of dataset. Qualitative analysis is based on judgement and experience of similar problems and its associated environment. Both analyses provide important information to the problem solver. However, many practitioners fail to give such qualitative analysis the same attention as the quantitative ones. This may be because qualitative analysis can be far more complex to undertake and more difficult to measure and assess. Additionally, the culture of certain organisations is such that credence is given to the quantitative instead of qualitative analysis (Koliza et al, 2004).

There are several tools that can be found with respect to literature in the field that attempt to simplify the task of qualitative analysis. Matrix data analysis is one technique to assist in developing a user-friendly method of displaying qualitative data. Using a matrix, information can be viewed diagrammatically and the strength of the relationship between variables illustrated. A multi-dimensional matrix is introduced here to assist in the resolution of New Product Introduction (NPI) related issues. Using such a matrix enables successful identification of problems and their related optimum solutions in the NPI business process. Furthermore, it enables the prioritisation of solutions to develop an improvement action plan.

8.6.1 Qualitative Analysis

According to Dey (1993), practitioners do not give qualitative analysis the same attention and commitment as quantitative analysis. Qualitative factors include any given number of "intangible" factors that cannot easily be measured or analysed numerically (although analysts often attempt to apply numerical measurements to intangible in order to facilitate analysis and/or comparison).

The core of qualitative analysis relies upon three related processes: describing and identifying phenomena; classifying it as well as evaluating the relationship between them.

The first step in qualitative analysis is to develop a thorough and comprehensive description of the problem under study. Geerz (1973) and Denzin (1978) call this the "thick" description. A "thin" description states "facts" and a "thick" description includes information about the context of an activity, the intentions and meaning that organise action, and its subsequent evolution.

Classification is the second process in qualitative analysis. Without classifying the data it is not possible to conduct meaningful comparisons between different pieces of data. Classifying data is an integral part of the analysis, it is the conceptual foundation upon which interpretation and explanation are based.

Conovey et.al. (1991), suggest that, we are so good at dissecting data that we often forget how to put the pieces back together again. This problem will not arise if description and classification serve the purpose of producing an account of the analysis. For that purpose connections need to be made among the building blocks of concepts of the analysis. A graphic, for example, representation is a useful tool in analysing concepts and their connections.

In order to analyse the available data it must be grouped or categorised. At this point similarities and relationships are identified and comparisons can be made between the different categories. If the data merits further differentiation then it can be sub-divided into subsequent sections.

Grouping data involves developing a set of criteria to distinguish observations as similar or related. This is done by developing a set of categories, with each category expressing a criterion for distinguishing one observation from others, as similar or related in some particular respect. Developing categories usually involves looking forwards towards the overall results of the analysis as well as looking backwards towards the initial dataset. Therefore, the process is one of continues refinement.

After creating and assigning categories, the analysis should be refined and focused. Tesch (1990), called this process *recontextualisation* of the data, in which the data is viewed in the context of the assigned categories rather than in its original context. In this process it is likely to produce a large amount of data assigned to one or more of the various categories used in the analysis. Furthermore, the data can be split up into a number of subcategories for clarity and practicality.

8.6.2 Qualitative Matrix

The relationship between categories of data are frequently very complex. To handle this problem *matrices* and *maps* may be developed. The matrices are used for making comparisons across cases, and maps for representing the shape and scope of concepts and connection in the analysis.

Typically, problems have several "dimensions" or interactive aspects. The difficulty is in sorting them out, to rank them and separate them. Matrix analysis is a set of tools for analysing data and for decision making. There are several tools of varying complexity that can used be as follows.

- A common way to weight or indicate relative importance (relative weighting) is to merely distribute points between the factors under consideration. This is an estimating procedure, common in market research and in customer focus groups. When carried out with a good sample of data it is possible to assign confidence limits to the results. This is a simple but useful technique.

- Pairwise comparison forces a more systematic consideration to be made, and therefore could be regarded as more reliable than point distribution described above. Pairwise comparison merely has a relative ranking as its outcome, not a relative weighting. It typically follows an Affinity exercise or a Tree Diagram exercise.

- Dimensional weighting converts the "whats" to "hows". The applications of this method are very wide. Apart from product design through Quality Function Deployment, other applications are selecting what sub-programmes are to be implemented as part of a Total Quality programme, for selecting suppliers and so on (Bicheno, 1998).

8.6.3 Qualitative Analysis within the Performance Measurement Method for the NPI process

Using the first three steps of the proposed method outlined above the following data can be obtained:

- Step 1 – Process Mapping: The issues that extend the time-to-market in the NPI process.

- Step 2 – Value Indicators: Their effect upon the company's cost base.

- Step 3 – Problem Solving: Possible solutions for each issue.

At this point the formulation of an action plan for improvement is necessary, particularly where more than one issue is identified.

To do so, qualitative measures need to be applied to the data derived in order to categorise and rationalise the issues and their possible resolutions. A multi-dimentional matrix can be used for this purpose.

Initially, the issues need to be prioritised according to their effect. A number should be assigned to every issue to indicate the loss it incurs the higher the number the higher the percentage of loss (L).

Then the possible solutions from the problem solving exercises can be assigned with a letter for each issue.

Next, the implementation of the solutions needs to be prioritised according to the estimated severity in order to resolve the issue.

Finally, the cost factor needs to be added. The solutions should be prioritised according to their estimated cost (material and resources) for their implementation.

The author developed a matrix that can be populated with the above information to indicate the best solution for each issue according to their optimum benefit.

From the data collated from the previous steps a matrix can be created to indicate the position of each point representing an issue and its corresponding possible resolution, in relation to time and cost. The Cost factor increases in value from the left to the right of the matrix. The Time factor increases in value from the top to the bottom of the matrix.

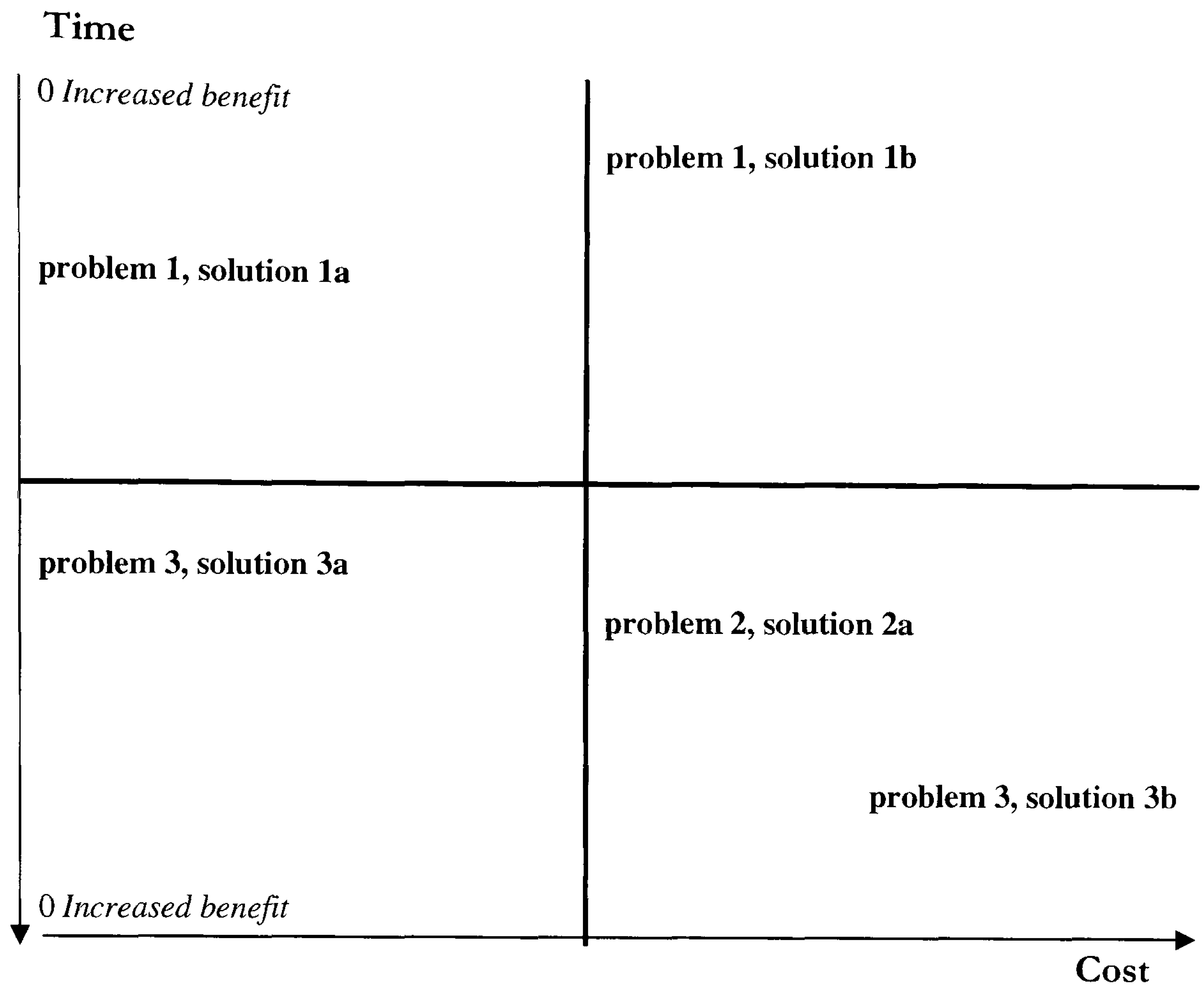

Figure 8.2. *Qualitative Matrix*

The target is to resolve the issues that will yield the highest benefit using the most efficient way. By observing the above matrix it can be seen at a glance, which are the issues with the highest factor that will reduce the overall costs of the company. The criteria that could be used for companies to identify their ideal solutions may vary. By reviewing the results of the value indicators obtained from the previous steps and by assessing the risks, the competition, the time-to-market and loss of opportunity, companies might decide to act differently under different circumstances.

8.6.4 Conclusion

By the use of the above matrix the data collected from the first, second, and third steps of the proposed method can be categorised and prioritised.

The aim is to assist in generating a priority action plan that will aid the identification of resolution of the issues according to the benefit that they are going to give, using the most efficient solution from those proposed.

The proposed qualitative matrix includes parameters such as; the affect of the issues upon the company costs, as well as the time and the cost factors related to the proposed solutions. It is a tool intended to assist in the identification of the tasks to be carried out, which would subsequently reduce process costs and could potentially improve the company performance.

8.7 Step 5: Quantify the Improvement Achieved

The purpose of this step is to review the effect of the improvements achieved through the first pass of the 4 steps of the method. The savings achieved through the improvement process are to be identified. The expected outcome of the whole process could be that the delay(s) identified and reviewed is completely eliminated, in other cases it could be that its duration has been reduced.

In the first scenario the value indicator for the losses incurred will automatically show the value of the sales turnover that can be realised. If the delay is substantially reduced in time the quantitative model and the value indicator can be reused and compared with the original figure. This comparison will show the effect of the improvement achieved.

8.8 Conclusions

This chapter described the method developed by the author that when followed inefficiencies of the NPI process can be identified, quantified, prioritised and resolved. The appropriateness of the concept of using such a performance measurement method specifically developed for the NPI process has been justified in chapter 4. The practicability of the usage of such a measurement method will be addressed on the case study that will be reviewed in chapter 10.

In section 3.2.2 of chapter 3 various criteria for effective performance measurement systems were listed. Some of those were that performance systems should:

- be related to the company's objectives.
- be clearly defined and easy to use.
- be designed so that they stimulate continuous improvement.

The performance measurement system proposed by the author meets these criteria since:

- it relates to reducing process costs which is one of the most common company objectives.

- the steps of the method have been clearly defined in this chapter and they have been applied without encountering any major difficulties in a case study (Chapter 10).

- the method is based on a continuous improvement cycle philosophy.

The following chapter will access the suitability of the method proposed depending on variations such as type of organisation, industry, process, product and other company characteristics. Moreover, boundaries and constraints will be identified that will indicate the extent that the concept can be put into practice.

Chapter 9

9. APPLICATION AND SUITABILITY OF THE VALUE INDICATOR PROPOSED

9.1 Introduction

The aim of this chapter is to assess the application and suitability of the value indicator of the performance measurement method proposed. The data gathered from the survey and the follow up interviews were analysed using Minitab and Microsoft Excel and the variables identified were varied in order for the value indicator to be calculated for each company.

The first analysis, single-level analysis, was focused into changing one variable at a time. However, in order to obtain a more realistic view the interdependencies of the variables were identified and a multi-level analysis was carried out. In this multi-level analysis all the variables were changed according to their relationship against the delay incurred in the process.

The multi-level analysis indicated that the company characteristics make the application of the value indicator more meaningful and useful for companies with certain characteristics. Despite this fact the value indicator proved to be applicable in all circumstances details of which are illustrated in section 9.4.1 with a summary in section 9.4.2.

9.2 Application and Suitability of the Method Proposed

Every company that offers new products or services to the market is involved in a NPI process, this would indicate that all of the companies will be able to utilise the method described in the previous chapters. However, when the effect of the delay was measured (using the data provided from the survey and the interviews) not all organisations experienced the same sensitivity to the delays that occur throughout the NPI process in relationship to the duration of their time-to-market.

Some of the elements that influence the effect of delays in different organisations are Size (in terms of turnover and number of employees), Market Positioning, Competitors, Product Price, Product Margin, Innovation, Volume of Manufacture, Product, Target Customers. All of these elements are company characteristics that are used to categorise different industrial segments. However, these elements do not define a company in isolation and should all be considered together. The data obtained from the written questionnaire as well as the follow-up interviews will be used to review the effect of delays throughout the NPI process. The effect will be measured, using the value indicators described in step 2 of the method, and will be compared against the relevant company characteristics. Similarities and differences are identified as well as patterns of sensitivity according to the delays and the company environment. This sensitivity analysis will highlight the suitability of the application of the method proposed.

9.2.1 Sensitivity Analysis

According to the SAF (2005), Sensitivity Analysis (SA) is the study of how the variation in the output of a model can be appropriated, qualitatively or quantitatively, to different sources of variation. Originally, SA was created to deal simply with uncertainties in the input variables and model parameters. Over the course of time, ideas have been extended to incorporate model conceptual uncertainty, i.e. uncertainty in model structures, assumptions and specifications. As a whole, SA is used to increase the degree of confidence in the model and its predictions, by providing an understanding of how the model outputs respond to changes in the inputs. SA is thus closely linked to uncertainty analysis, which aims to quantify the overall uncertainty associated with the response as a result of uncertainties in the model input (Salteli et.al. 2004)

The data provided by the survey and the follow up interviews discussed in chapters 6 and 7 was fed into the model described above. This process produced the value of Loss as a percentage of the Sales Turnover due to the delays identified for each of the companies within this study. Within this research, in order to compare the results and to understand the underlying data provided better, they were exposed to different types of analysis.

The first step was to analyse the sensitivity of the variable elements of the formula for each company classification independent of any other influences. This single dimensional analysis allows monitoring of each individual variable while all the rest remain constant. This analysis provides a basic understanding of the relationship between the variable and the resulting values. A number of variables were identified that were then subject to further multi-level analysis.

The sensitivity analysis used the most commonly applied range of variable change. Changing the variables by –30%, -20%, -10%, the base value, +10%, +20% and so on, several runs of the data were made. The results were then compared to the results of the original data set.

9.2.2 The Variables

The formula utilised to calculate the loss of sales turnover due to delays that occur in the new product introduction process were reviewed in order for all its variables to be identified.

The variables to be monitored in this analysis are as follows:

- The Delay: this is the value of the delays in hours that occur throughout the new product introduction

- The Penalties: this is the value of liquidation damages as a percentage that certain companies are contractually required to pay in order to compensate their customers for late products or services. *The value of the liquidation damages in pounds is calculated by taking into account the number of orders that are late, their value and the percentage that the company has to compensate.*

- The Order Intake: this is the number of orders received for the year.

- The Average Order Value: this is the value in pounds of an average order.

- The Delivery Adherence: is a percent that represents the quantity of products and services that are delivered late to the customer. *From this value the number of late orders can be derived which is calculated using the order intake value*

- The Lost Orders: this is the number of customer orders lost due to the extended delivery times quoted.

- The Price Reduction: this is the value in £ that companies have to reduce their prices by to compensate for their products or services reaching the market later than their competitors.

- The Turnover: this is the overall sales turnover that is calculated based on the sales achieved throughout a year.

All variables are increased or decreased by the same amount or percent so that their effect can be analysed for all the different companies and industries.

9.3 Single Level Analysis Results

The Delay: The delays that occur during the new product introduction process have a linear relationship to the loss calculated. Therefore, the loss is directly associated with the increases or decreases of the duration of the delay. An increment in the delay of 100 hours resulted in an increase to the loss between an insignificant value, to a value of 0.08 percent for different companies, as illustrated in figure 9.1. As illustrated on the graph when the Overall Turnover is greater than £50M the significance of the delay becomes minimal.

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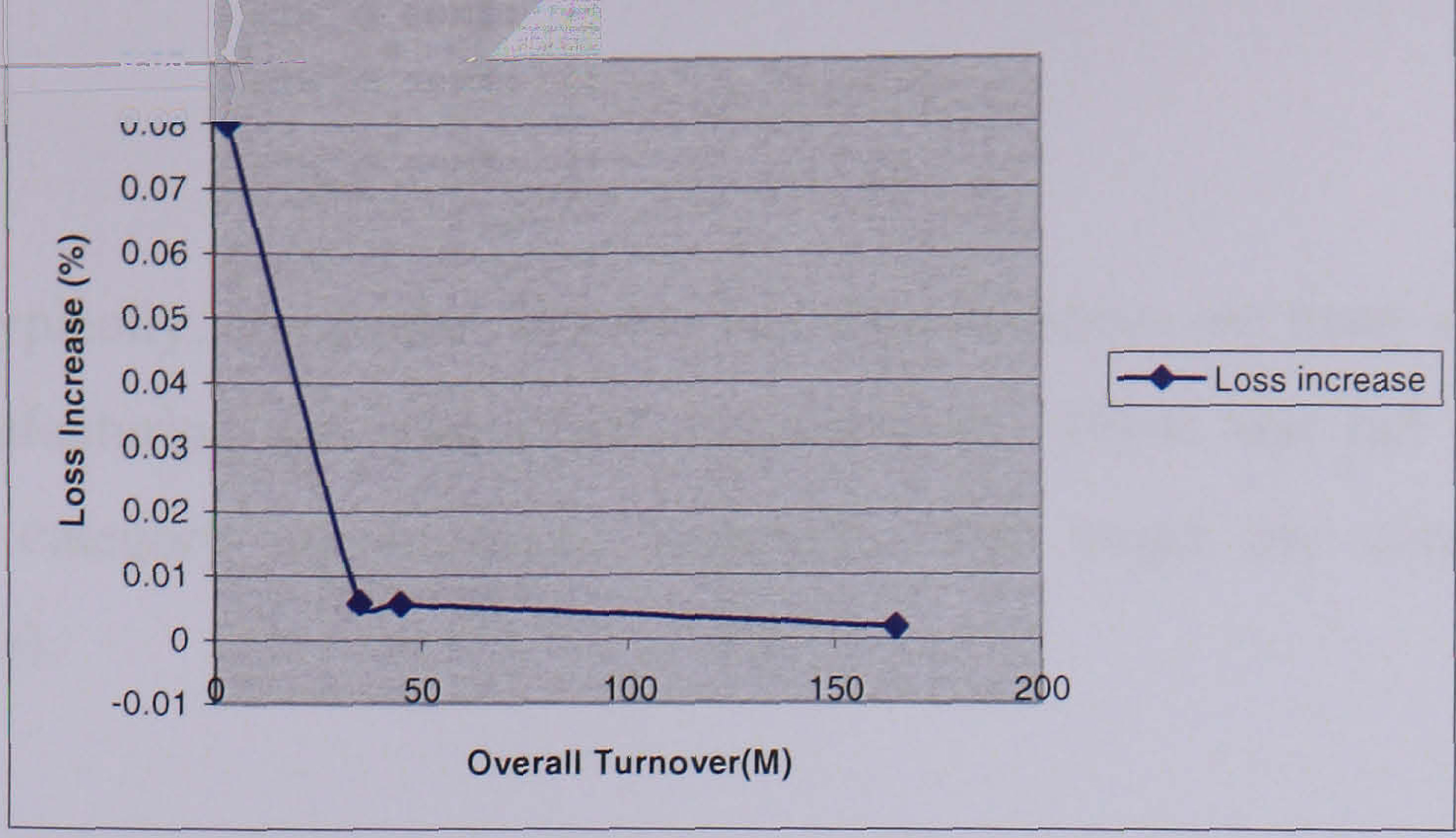


__Figure 9.1.__ Loss vs Overall Turnover with Variable Delay

The sales turnover in this case is the main factor that provides a buffer to a company's inefficiencies throughout the product lifecycle. From the graph shown above it can be seen that the companies with the higher turnover can absorb the effect of the increasing delays with no detrimental results. However, the company at the bottom of the range realises a considerable amount of loss in profitability from an increase of 100 hours of delay, which is just between 12 to 13 days of delay in their NPI process. Therefore, larger companies that are market leaders and achieve a higher overall sales turnover are more resilient to increases of the delays in their new product introduction process.

The Penalties: If penalties occur, they also have a linear relationship with the loss. By increasing the value of the liquidation damages the loss increases accordingly. An increment of 0.5% on the value of the average customer order has resulted in a variance on the loss of between 0.0035 and 0.01 percent.

Since the penalties are expressed as a percentage of the average order value, then the companies that are affected the most are those with fewer high value customer orders than those with a great number of lesser value ones. Typically, companies with the first characteristics are those involved in manufacturing and specialised niche markets. Those that fall into the second category are normally companies that target the consumer's market(s).

The Order Intake: In this mono-dimensional analysis the order intake does not influence the loss at all. However, in a real life scenario the order intake will influence values such as late deliveries, number of late orders or orders lost. In addition, the price reduction figure will be affected since it is linked to the number of orders lost. All of the above figures could influence the loss figure considerably. Further analysis on this variable is required for its effect to be evaluated confidently. This analysis will be discussed on the multi-level review on section 9.4.

The Average Order Value: The average order value has also a linear relationship to the loss. This is the case when orders are lost due to the time to market delays. If no order loss occurs, then the overall turnover will not be influenced. For example, a one percentage increase in the average order value results in an increase in the loss of profit between 0 and 2 percent. Obviously, the number of orders received is the element that varies the results for each company. Figure 9.2 below shows that for the average order value variable, as the order intake increases the loss decreases.

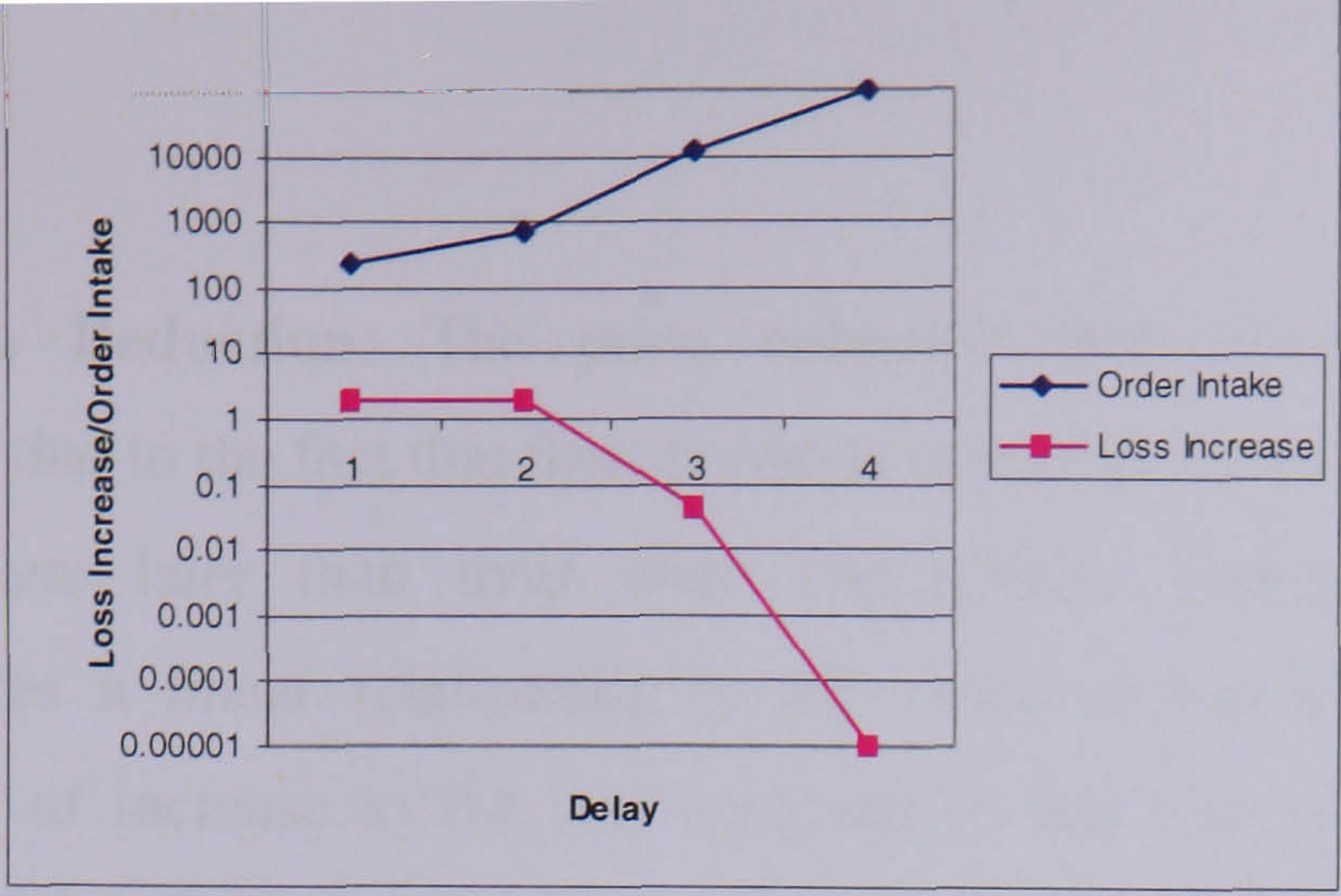


Figure 9.2*. Order Intake and Loss relationship with Variable Average Order Value*

The Late Orders: In this mono-dimensional analysis the number of late orders does not influence the loss at all. However, in a real life situation the number of late orders will influence the value of the penalties, assuming that the company has to compensate their customers for late deliveries. This will also be taken into account on the multi-level analysis. The penalties will increase the value of the loss. Therefore, the trend for the fluctuation on the number of late orders in a realistic scenario will follow the liquidation damages behaviour.

The Orders Lost: The number of lost orders has a linear relationship to the turnover loss. By analysing the results from this study it has been observed that an increment in the number of orders lost of 10 results in a variable increase between 0.01 to 1.5 of the turnover loss percent. In this case companies with large number of order intake will not be dramatically influenced by this variable, since this large number of orders will generate a buffer against the costs of the delay.

The Price Reduction: The price reduction that occurs in certain companies due to the fact that their products or services were introduced to their markets later than their main competitors, unsurprisingly also demonstrates a linear relationship to the value of loss of profit. The percentage of increase to the loss observed in this case varies between 0.035 to 0.5 percent. A combination of the number of orders received and the average order value defines the effect of the increase of the price reduction to the profitability loss figure.

The Sales Turnover: As expected the increase of the overall sales turnover absorbs the effect of the delays and their effect to the loss value. The reduction of loss has an exponential relationship to the turnover as illustrated in figure 9.3 below.

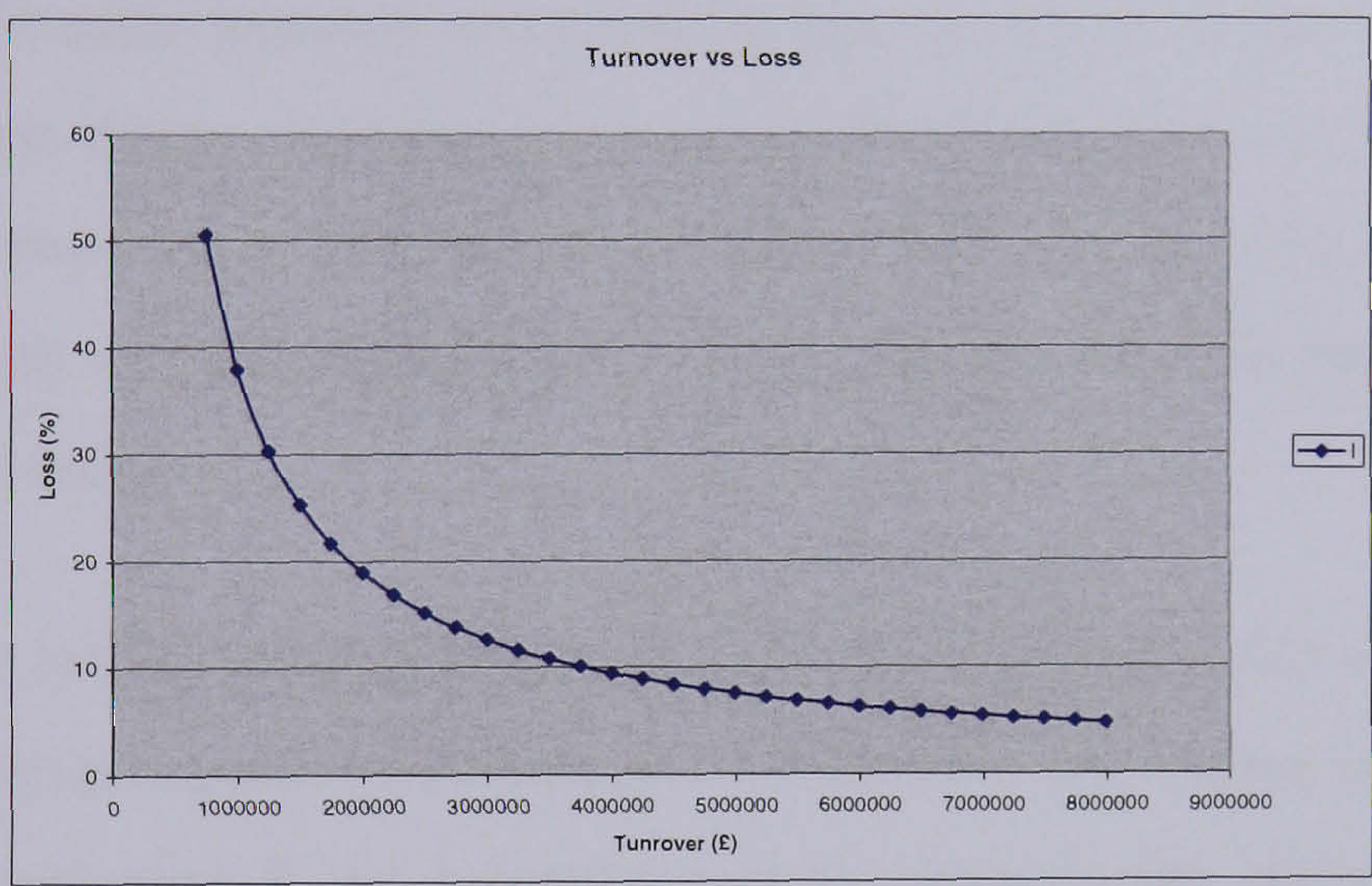


Figure 9.3. *Sales Turnover vs Profitability Loss*

9.3.1 Conclusions

From reviewing the results of this study it is evident that the actual direct costs attributable to delays in the new product introduction are much less than the potential losses due to the delay. The fact that the full effect of the delay is not obvious at the time it occurs, provides a false impression about its significance. According to the data from the case studies an amount of these potential costs does materialise, which is represented by the percentage of loss represented here.

An increase in the sales turnover can reduce the value of the profitability loss. However, the ways by which such increase occurs can have a varying degree of influence on the percentage of reduction of loss. For example, if the increase in sales turnover is a result of process improvement that has reduced process delays, then the above figure 9.3 (Sales Turnover vs Loss) will apply. However, if the increase is the result of an increase in order intake only then will the reduction rate will be smaller, since the risk of late deliveries will increase.

Following the last comment through, it has been highlighted that all of the variables observed cannot be considered in isolation. The degree of loss in profitability may vary if the interrelationships between the attributes are considered.

9.4 Multi-Level Analysis

Characteristics inherent in the NPI process that may facilitate or hinder the implementation of the method proposed will also be discussed here.

Finally, the question as to whether it is possible to institutionalise the practice of the proposed method will be reviewed.

In order for the multi-level analysis to take place the elements that are interdependent and those that could be derived by other variables were identified. This exercise identified those variables that needed to be fluctuated and those that had to be calculated according to the value indicators described in the previous chapter.

The variables in this analysis are:

- The delay in hours.
- The percentage of late orders.
- The number of orders received per year.
- The number of orders lost.
- The company's turnover.

Those variables that will be derived by the formulas described in chapter 8, and are dependent upon the values of the above variables, are:

- The actual costs.
- The number of late orders.
- The amount of order loss in pounds.
- The loss incurred due to the delays identified.

9.4.1 Multi-level Analysis Results

The data that was provided by each company through the survey and follow up interviews was used to calculate and present case examples based on the variables described above. The calculated value indicators in this case indicate that the effect of a delay in the profitability is highly dependent upon the company characteristics. The companies chosen to carry out the multi-level analysis were companies C, D, F, G and H. The characteristics from these companies were representative of the 8 companies studied based on market and products. Company A has been further analysed in the case study described on chapter 10. Due to the data protection and the nature of business of Company B did not allow for further analysis in this area. The order by which the findings are presented is by company characteristics.

The following were observed by the review of the data gathered.

COMPANY C

The first case reviewed was that of company C. The characteristics of this company are:

- Very high sales turnover (in excess of £1B).
- No order loss due to length of time-to-market.
- No price reductions due to length of time-to-market.
- Stable order intake.
- No compensation for late orders.

The indicators calculated for this company case show that the effect of the delay(s) encountered throughout the duration of the NPI process has a negligible effect to the company's profitability (figure 9.4 and 9.5). The costs incurred in this case are the actual costs based on the resources utilised which in relation to the company's wealth is of a minute importance. These findings were consistent with the findings from the follow up interview with the participant from this company.

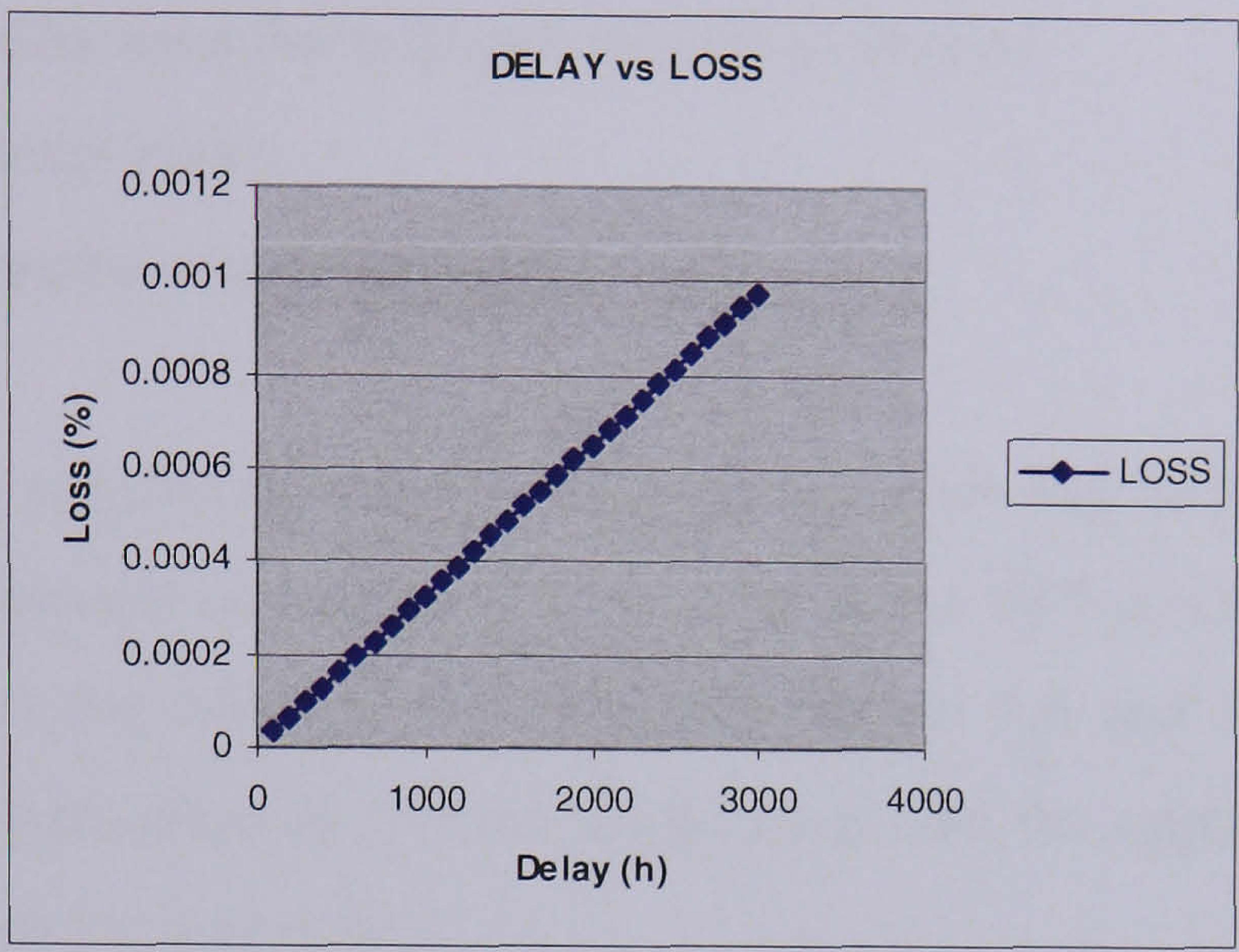


Figure 9.4. *Delay vs Loss for Company C*

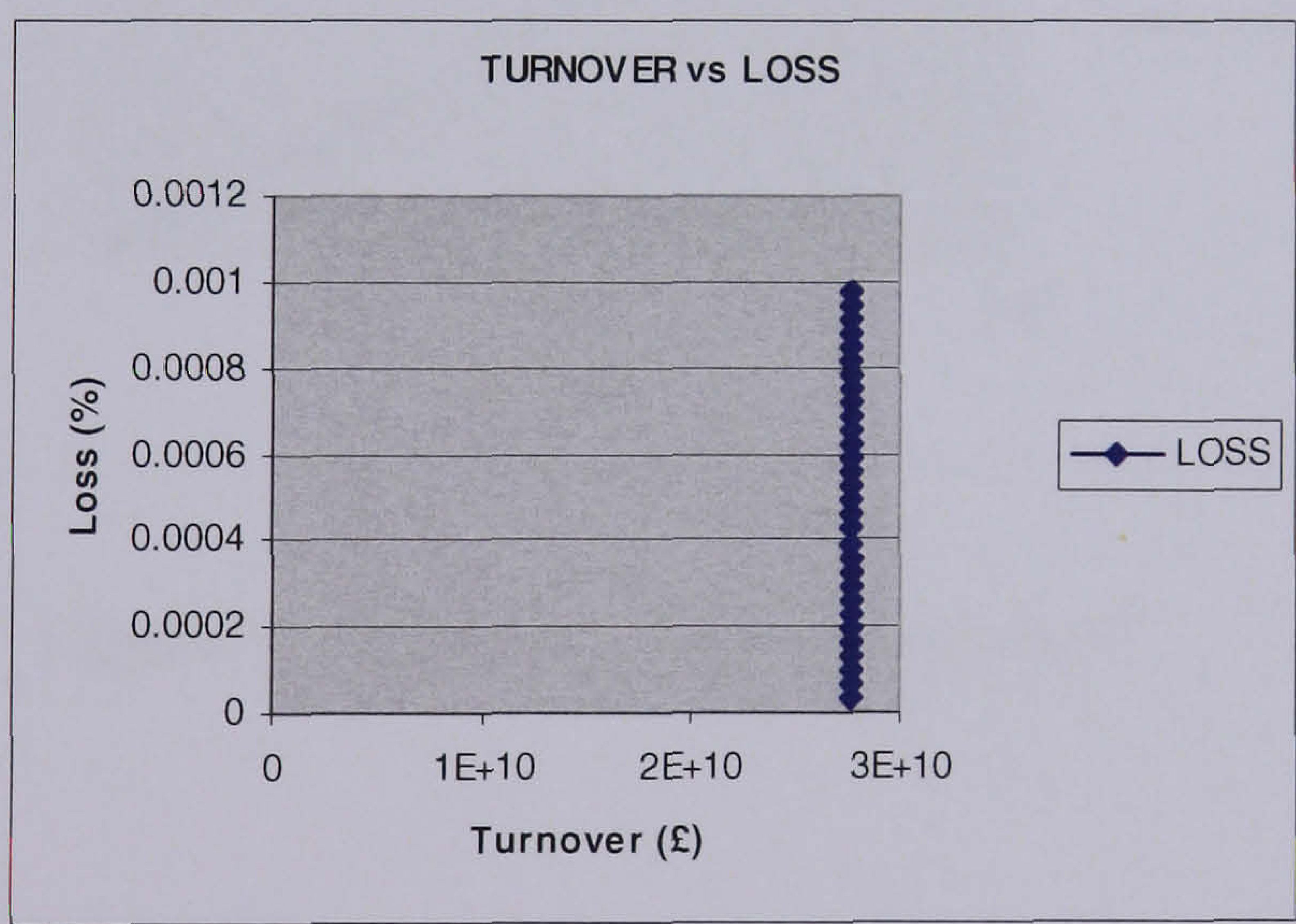


Figure 9.5. *Turnover vs Loss for Company C*

COMPANY F

The second case reviewed was that of company F. The characteristics of this company are:

- High sales turnover (in excess of £200M).
- Some order loss due to length of time-to-market.
- No price reductions due to length of time-to-market.
- Variable order intake.
- No compensation for late orders.

The indicators calculated for this company case show that the effect of the delay(s) encountered throughout the duration of the NPI process has very small effect to the company's profitability (figure 9.6 and 9.7). In this instance the costs incurred are the actual costs and the opportunity loss costs realised due to lost orders.

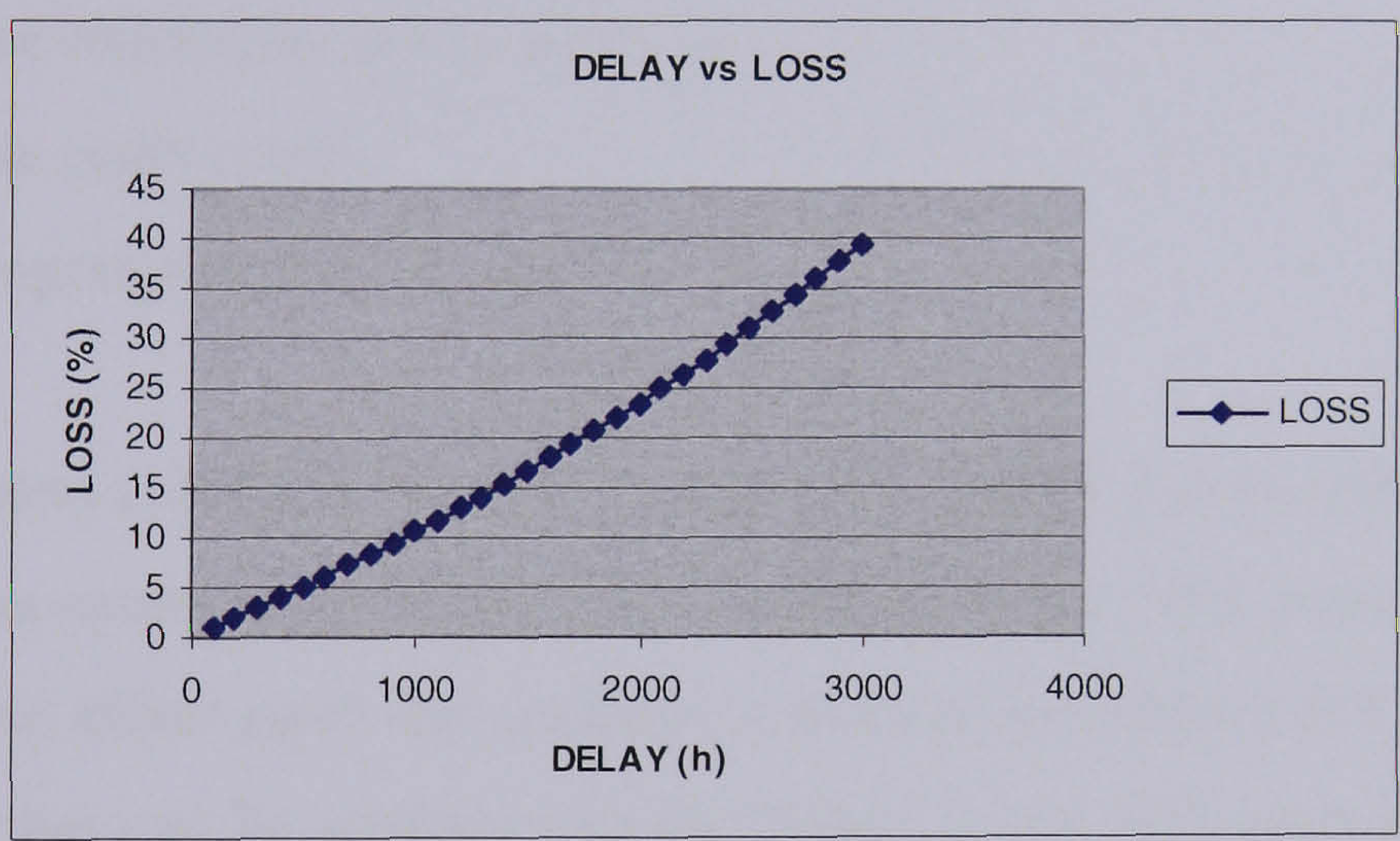


Figure 9.6. Delay vs Loss for Company F

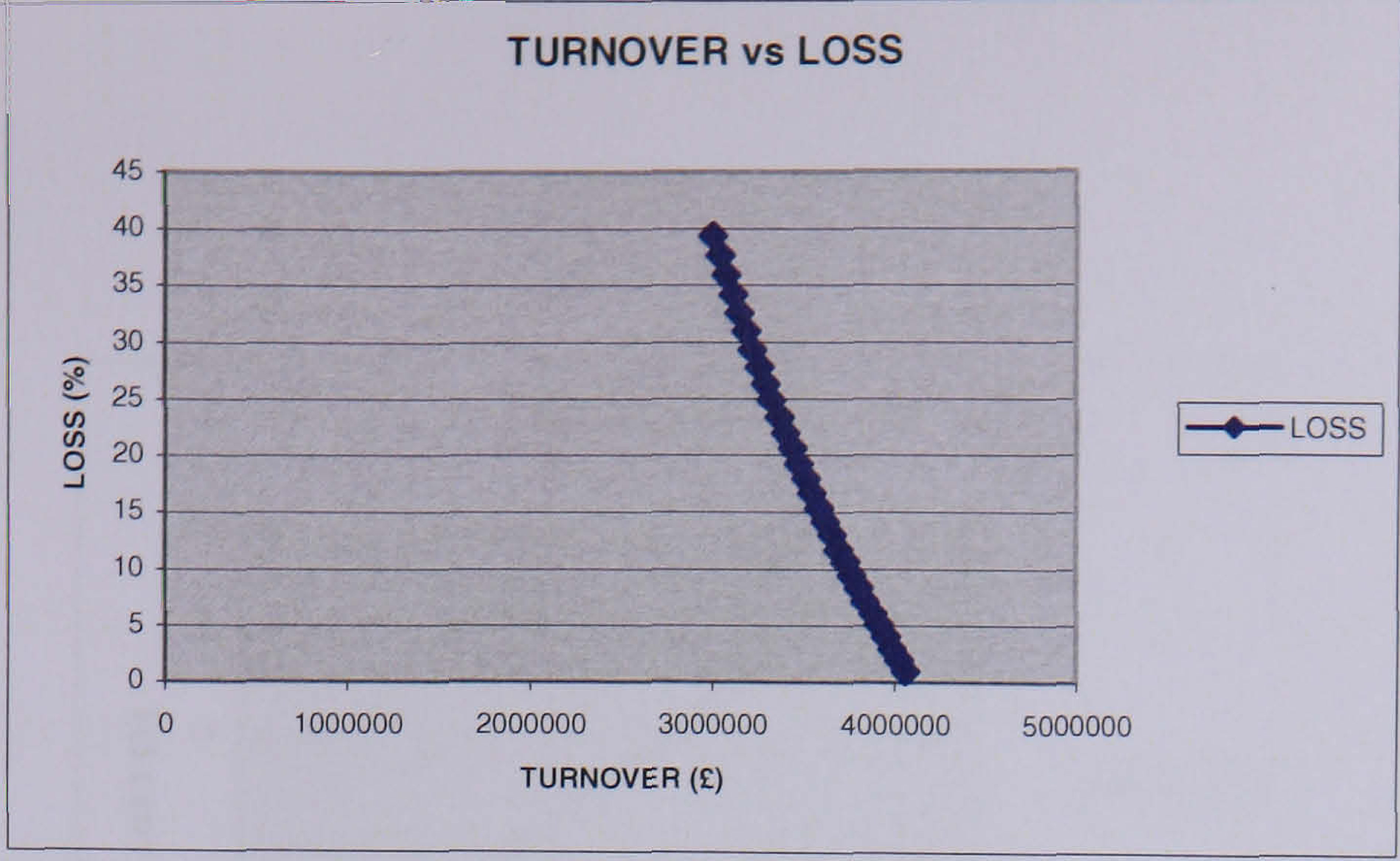


Figure 9.7*. Turnover vs Loss for Company F*

Company D

The third case reviewed was that of company D. The characteristics of this company are:

- Medium sales turnover (between £35M to £200M).
- Some order loss due to length of time-to-market.
- No price reductions due to order loss.
- Variable order intake.
- No compensation for late orders.

The indicators calculated for this company case show that the effect of the delay(s) encountered throughout the duration of the NPI process has a considerable effect upon the company's profitability (figure 9.8 and 9.9). The costs that can be attributed to the delays in the NPI process for this company are the actual costs and the costs due to opportunity loss as in the previous case for company F. However, the difference between company F and company D is their sales turnover. Company D has a reported turnover figure that is 30% less than that of company F, this is the only company characteristic that is different between the two companies.

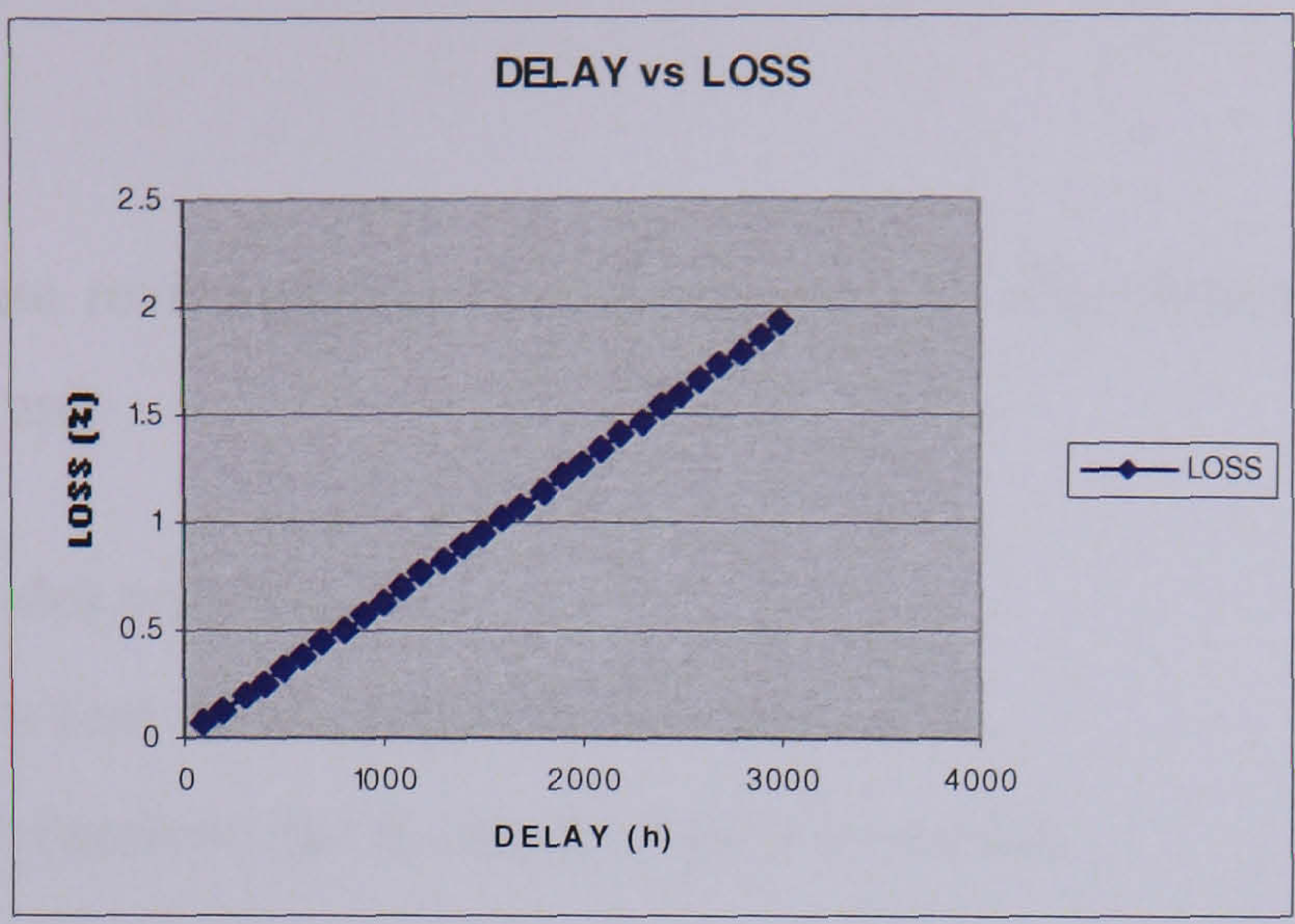


Figure 9.8. *Delay vs Loss for Company D*

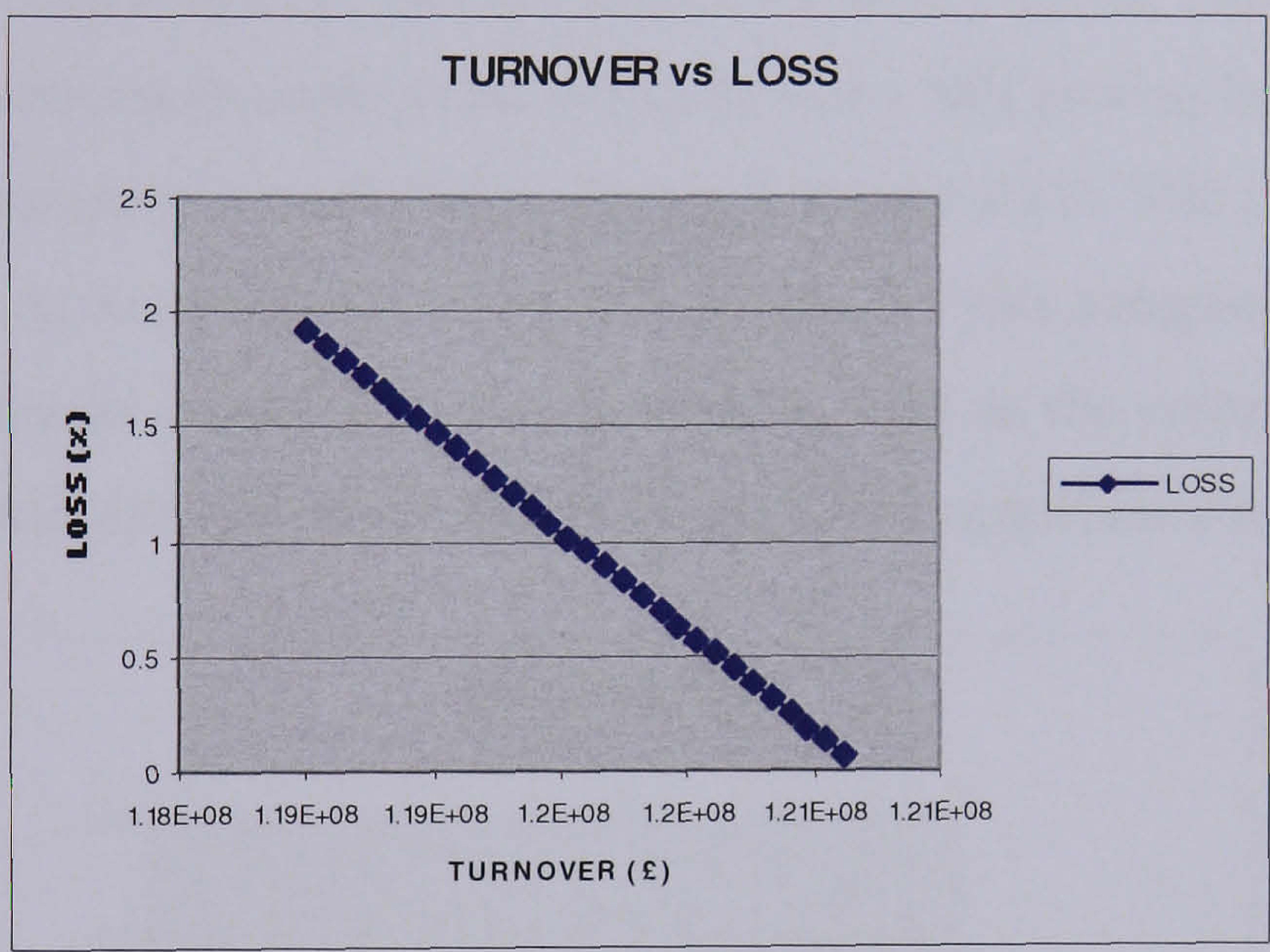


Figure 9.9. *Turnover vs Loss for Company D*

COMPANY G

The fourth case reviewed was that of company G. The characteristics of this company are:

- Medium sales turnover.
- Some order loss due to length of time-to-market.
- No price reductions due to length of time-to-market.
- Variable order intake.
- Compensation for late orders.

The indicators calculated for this company case show that the effect of the delay(s) encountered throughout the duration of the NPI process has a high effect to the company's profitability (figure 9.10 and 9.11). The costs that can be attributed to the delays in the NPI process for this company are the actual costs due to additional resource used as well as the compensation paid to customers for late orders and the costs due to opportunity loss.

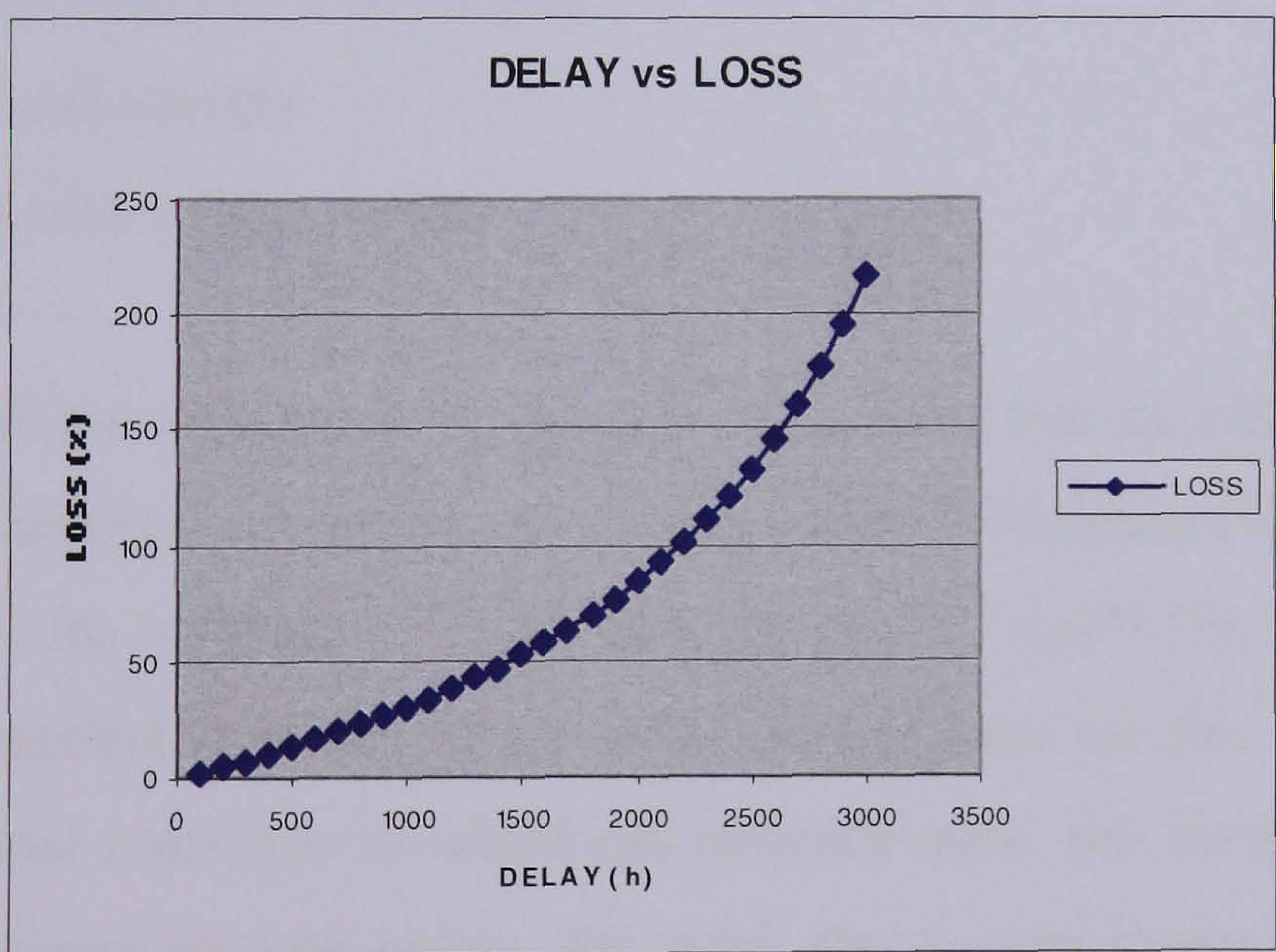


***Figure 9.10**. Delay vs Loss for Company G*

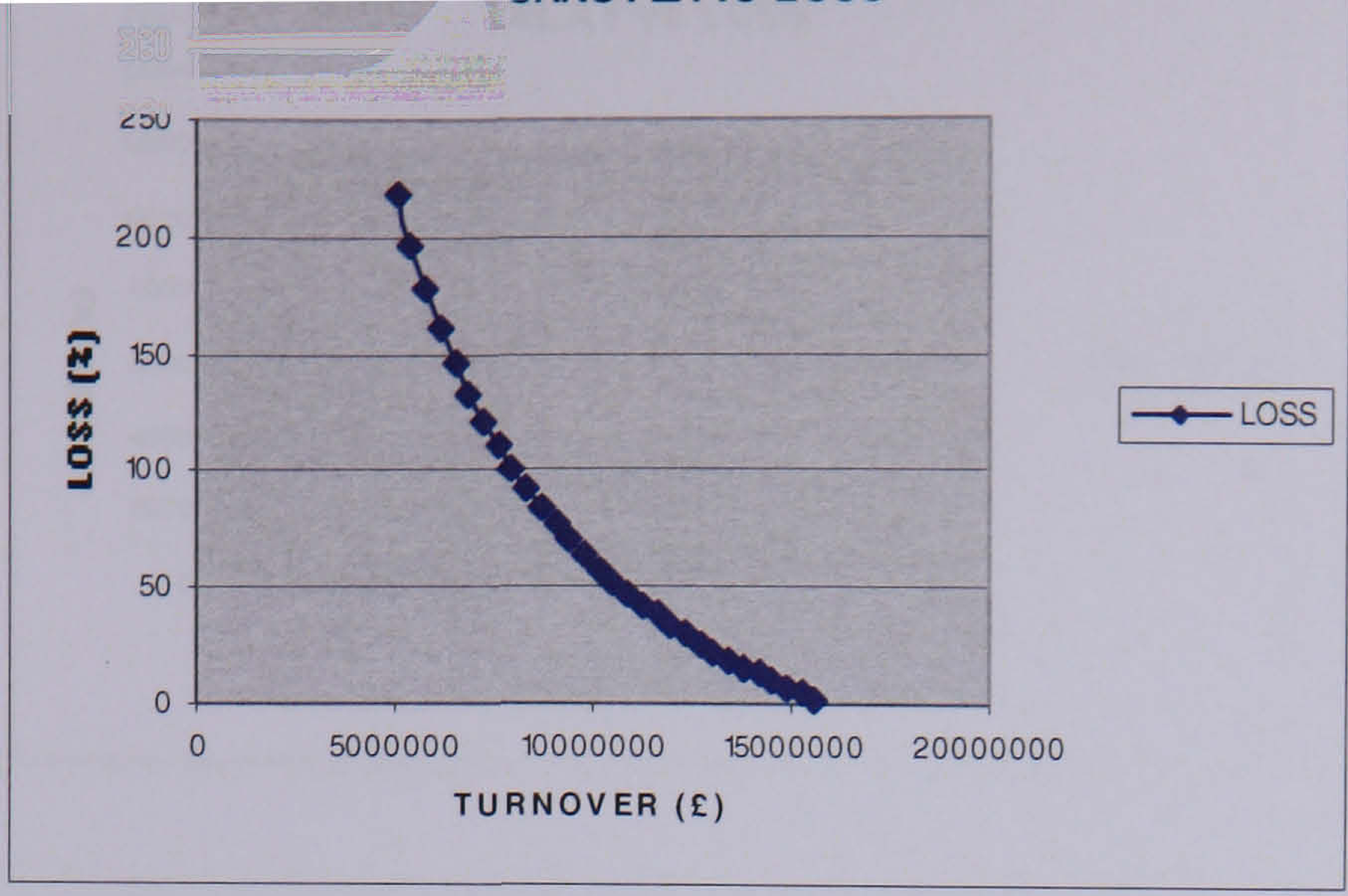


Figure 9.11. Turnover vs Loss for Company G

COMPANY H

The fifth case reviewed was that of company H. The characteristics of this company are:

- Medium sales turnover
- Some order loss due to length of time-to-market
- Price reductions due to order loss
- Variable order intake
- Compensation for late orders

The indicators calculated for this company case show that the effect of the delay(s) encountered throughout the duration of the NPI process had a very high effect on the company's profitability (figure 9.12 and 9.13). The costs that can be attributed to the delays in the NPI process for this company were the actual costs due to additional resource used, the compensation paid to customers for late orders, the costs due to opportunity loss and pricing reduction of products that were late to reach their target market.

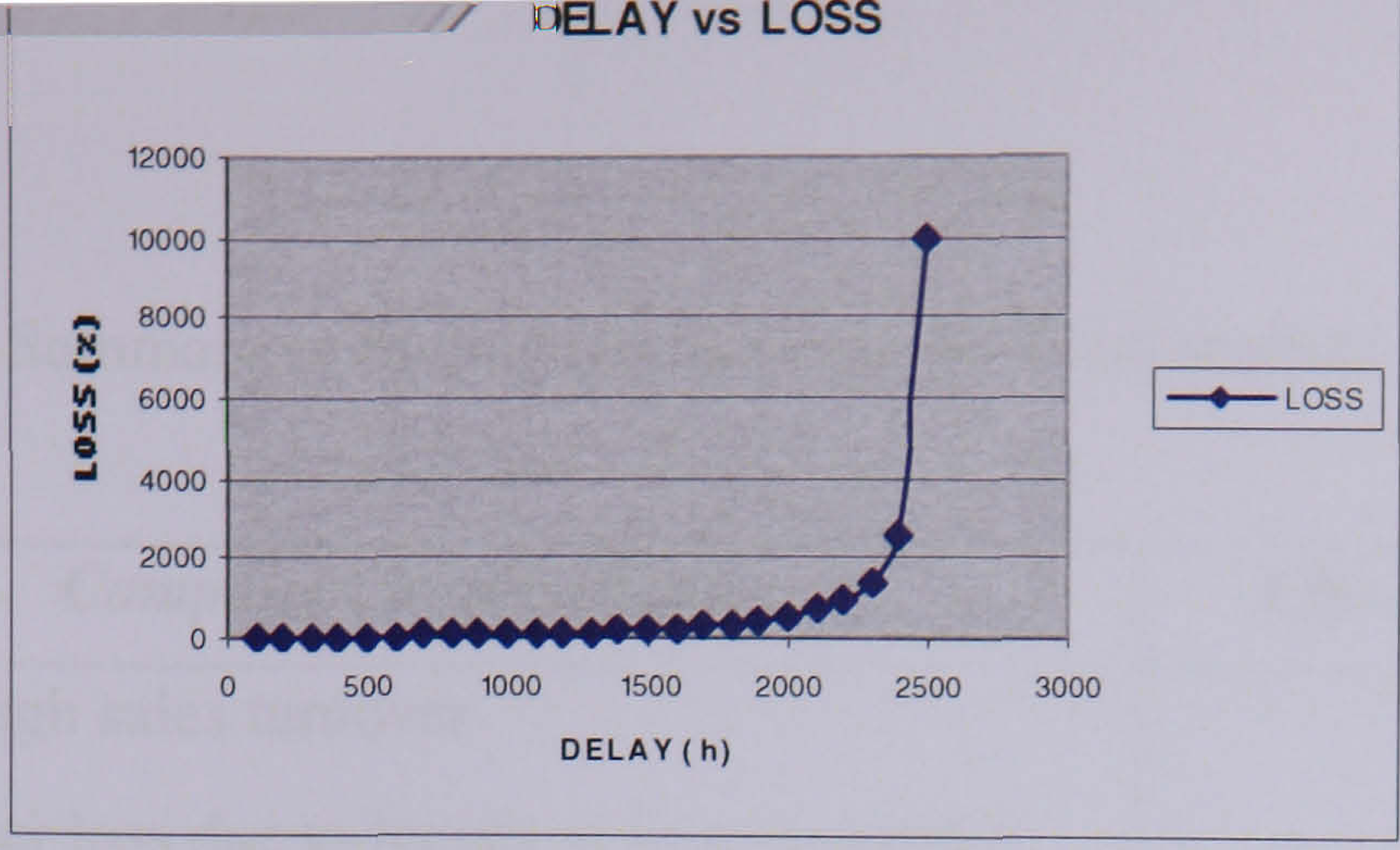


Figure 9.12. Delay vs Loss for Company H

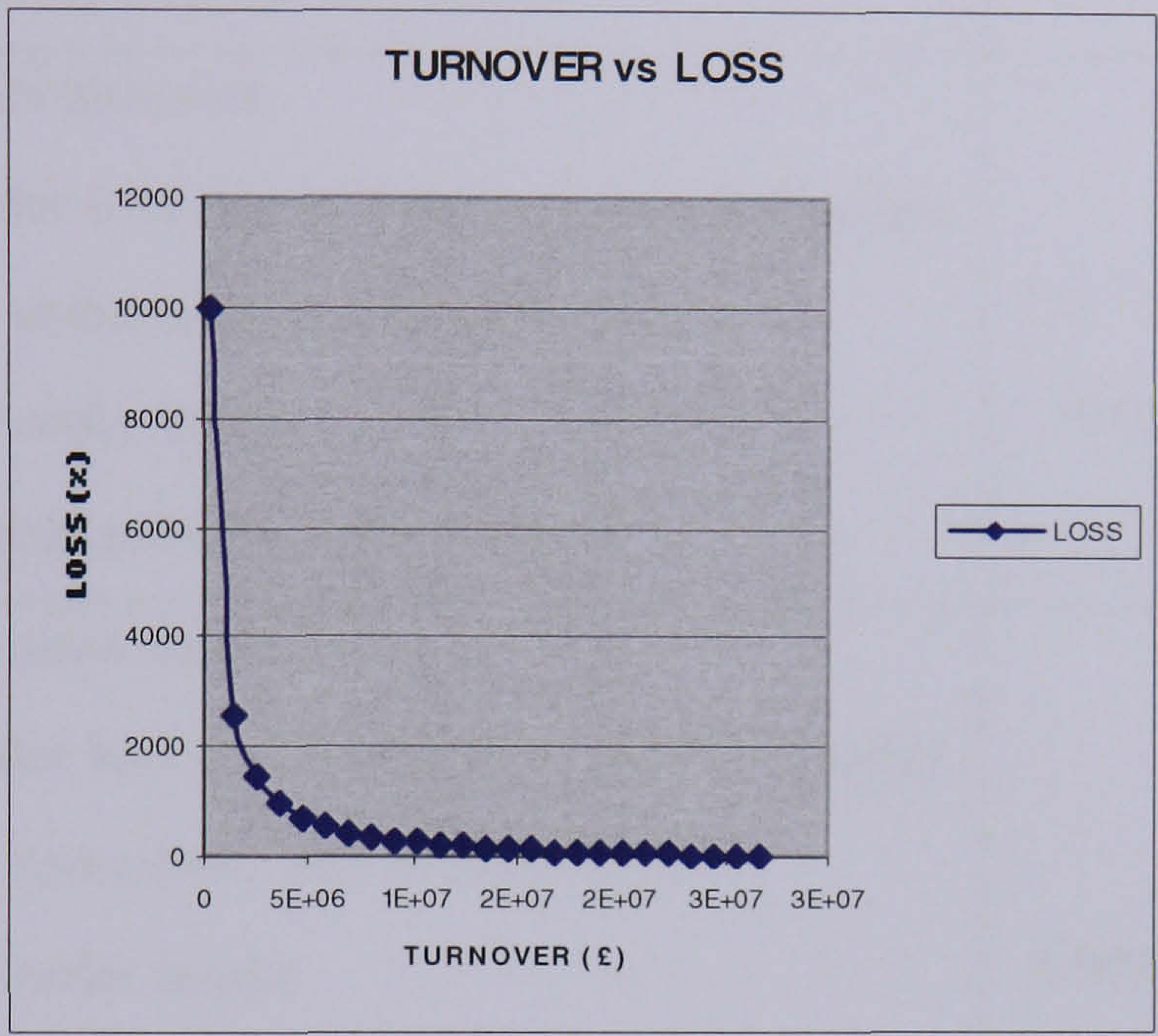


Figure 9.13. Turnover vs Loss for Company H

9.4.2 Summary

From the findings in section 9.3 it is evident that specific company characteristics have an influence on the effect of delays that occur throughout the NPI process. The following table summarises the results.

Table 9.1. Summary of findings from the multi –level analysis

Company Characteristics	*Effect of delay*
• Very high sales turnover • No order loss due to length of time-to-market • No price reductions due to lost orders • Stable order intake • No compensation for late orders	Negligible effect
• High sales turnover • Some order loss due to length of time-to-market • No price reductions due to order loss • Variable order intake • No compensation for late orders	Very small effect
• Medium sales turnover • Some order loss due to length of time-to-market • No price reductions due to order loss • Variable order intake • No compensation for late orders	Considerable effect
• Medium sales turnover • Some order loss due to length of time-to-market • No price reductions due to order loss • Variable order intake • Compensation for late orders	High effect
• Medium sales turnover • Some order loss due to length of time-to-market • Price reductions due to order loss • Variable order intake • Compensation for late orders	Very high effect

These findings are based on aggregate data provided by the participant companies. This is due to the lack of information systems in place to provide more specific data and monitor the NPI process. However, aggregate review influences the results, since the overall figures would mask problems in individual new product introductions. The power of the method proposed along with its indicators would be further realised if product or product family related information is used.

9.5 Conclusions

In this chapter the data collected from the survey as well as the follow up interviews were used to validate the suitability of the value indicator developed (chapter 6). The value indicator was successfully used for all the companies that participated irrespective of their individual company characteristics. A single-level analysis was undertaken to review the sensitivity of the indicators when the variables were changed.

In the single-level analysis each variable was altered independently of the rest. However, by the end of this exercise it was evident that such a hypothesis does not represent a real life scenario since more than one variable is related to the others. A multi-level analysis then followed that yielded more valuable and realistic results.

The results from the multi-level analysis demonstrated that the indicators can be used by any type of company and for any NPI process utilised. The indicators are adaptable enough to tailor the results dependant on the unique characteristics of each company.

The most important finding from this analysis was the evaluation of the value indicator that forms step 2 of the model for each case. It is evident that the unique company characteristics make the application of the method and the use of the results important or not. As demonstrated above based on aggregate set of data, a company with a very high turnover figure, a stable market with time-to-market that does not pose an issue on the indicator value, although a loss figure will be produced it will be of no significance to the overall profitability. On the other hand, when used in a company with a variable market were time-to-market is key and customers are compensated or prices are dropped to counteract lateness then the indicator offers a very valuable estimate of the losses incurred. However, it is advisable that the indicators are reviewed using product specific data. This product specific data needs to be provided for the indicator to be produced. This data could be part of the business information system with inputs and outputs to include the variables identified in section 8.4.

The findings of this exercise also correlate with the data collected by the postal survey and the follow up interviews that validated the data provided and expanded upon it providing further detail. Also, the results are in accordance with expectations and current literature on the subject. Since the findings are consistent with the literature and the participants' experience they correspond to reality and are therefore valid.

The next chapter will describe a case study carried out in company "A" that followed through all the stages of the performance measurement method proposed. Company "A" found the exercise extremely useful and actions were created to improve the NPI process that was followed.

10. A CASE STUDY

10.1 Introduction

The performance measurement methodology described in chapter 8 was put into practice in company A. The purpose of the case study was to test both the theoretical performance measurement model proposed as well as the practical application of such a methodology within a company's environment. This chapter will describe the application of the methodology and the lessons learnt from this exercise.

A team from Company "A", was assigned to undertake this case study which included the design of the NPI process and the evaluation of the proposed performance measurement methodology. The length of the project was just under 18 months and a number of improvement opportunities were identified. Each step of the methodology was applied and it will be described in the relevant sections of this chapter.

Through the application of this methodology in Company "A" it became obvious that there were a number of enablers and inhibitors in the team tasked to carry out this case study.

10.2 Case Study in Company "A"

10.2.1 Company Background

The environment of Company "A" is described in detail in section 6.4.1. Points to note about Company "A" are that it is a medium sized organisation manufacturing detection equipment for a number of different chemical and biological agents. In 2003 the company had 350 employees and a turnover of £50M. The author was a full time employee of this company, which offered an excellent opportunity to carry out detailed review and analysis of the application of the performance measurement methodology for the NPI process proposed in this thesis.

In September 2003 a team at Company "A" was tasked review the current loosely documented NPI process and where possible introduce new procedures that will improve the performance of the NPI process and thus the overall company results. This activity gave the opportunity to test the methodology developed by the author and check its applicability and suitability in a realistic company environment.

10.2.2 Step 1: The development of the NPI process in Company A

Since the NPI process encompasses all the events from the initiation of a product idea to its production, it manages the working practices of several functions within an organisation (Trott, 1998). Therefore, the agreed way of developing such a process in Company A was by forming a cross-functional task force that would include representatives of all those areas involved. However, developing such a process was not an easy task due to the effort and time required.

Unsurprisingly, the cross-functional team had the characteristics of every group of people brought together to complete a task such as: a general lack of understanding and knowledge of best practice NPI routines, resistance to change, departmental interests, different functional priorities, cost justification issues, and various on-going projects.

To help overcome these retarding forces, the introduction of a formal NPI process needed the full support of top management throughout the implementation project. Only top management was able to resolve the interdepartmental issues that arose from company-wide use of the NPI process. However, top management could not be expected to be involved in all the details of producing and implementing the best-fit NPI process. Therefore, this task was delegated to a task force (NPI Task Force) that was responsible for developing a NPI process and its implementation plan. The process would define the role of New Product Introduction in the company, and would outline the corresponding organisational and policy requirement.

The task force included competent and powerful individuals from all the functions that initiate, create, produce and distribute new products. These functions include Programme Management, Scientific, Quality Assurance, Production Control, Sales and Marketing, Purchasing, Engineering (Mechanical/Electronics and Software), Production Engineering, Process Engineering, Integrated Logistics Support, and Production Management.

It would also have been useful to include in the task force a relevant employee from the customers and any others that would be affected by the new process outside the company. This could have proved useful due to the complexity of the product and the constant communication that had to happen between the company and the customer off-line. However, for the reasons of unavailability and time constraints, this wasn't possible. Instead, the appropriate members of the task force were contacting the customer to obtain the required information when necessary.

Top management defined the objective and authority of the task force. The objective of the task force was the "Introduction of a structured and commercially effective NPI process". The task force was led by a Programme Manager, and met regularly.

The development and implementation of a NPI process is a long-term activity that should take place only once. It should be run as a well defined, company-wide project. Therefore, a task force secretary was appointed, reporting to the task force leader that run it's day-to-day activities, as well as documenting all the developments after every meeting. A project plan was also drawn up showing the major milestones, resources, activities and costs. The plan was kept up to date and visible. Top management was informed of what progress was made, and was aware of any problems that arose during the development.

10.2.2.1 NPI Task Force Activities

All the members of the team attended training in order to familiarise themselves with current best practices of NPI and engineering development processes.

An early activity of the task force was to carry out a brainstorming session that indicated potential scope areas of application, costs, and benefits. Another was to inform through a company briefing all those that would be affected by the activities of the task force. If users are aware of potential changes before they take place and are asked for their help, they are usually willing to contribute and, by doing so, become involved and familiar with the eventual solution.

The project was split into a three-stage process, due to the level of resources required and their specific skills.

- The first stage, in which the task force played a major role, led to the development of the NPI strategy and process that addressed technological, organisational, and financial issues. It also provided a long-term implementation plan.
- The second stage started from the high-level results of the first phase. A new task force, containing some members of the original task force and some other practitioners, were to translate the high-level plans into detailed actions.
- The third-stage was to see the NPI process in everyday use. This led to requests for modifications and further improvements. By the end of the third phase an established well working process was to be in place. Another task force activity was to define *do's and don'ts* that had to feature or be avoided in the new process. The most important of these were the following.

The essential elements for superior product development were defined as (Wilson, 1996):

- Control by a cross-functional team. This team should integrate broad skills needed to develop successful products, as well as controlling all aspects from technology selection to manufacturing.
- Creation of a vision for the new product. It is very important to identify customers' future needs and the team should directly participate in future need projection. Customers should provide direct input to the team members, by providing an as accurate as possible requirements list as well as by participating in the open design reviews offering valuable comments for further development and improvement.
- Information convergence at the product definition phase. The team should consider all the critical issues early and simultaneously. Then common goals and plans are established via consensus.
- Information continuity for critical product characteristics.

Typically ineffective approaches to product development were defined by the task force that correlate to the literature (Millward et al, 2005) as:

- An overly rigid process characterised by complex inflexible procedures, such as overly descriptive design development processes, and costly, time-consuming enforcement mechanisms;
- A group-dominated process where a single group (e.g. marketing, R&D, or manufacturing) is stronger than other functions and dominates decision making; or
- No process at all, which often results in product lacking key customer benefits, erratic organisational performance, and poor product performance.

The author agrees with the above points. A process that does not allow any flexibility is not appropriate for the majority of organisations. An external change such as market and customer requirements along with new competitors entering the market and globalisation requires companies to adapt their NPI processes to remain competitive. The process should also be impartial to any of the departments or functions that are required to carry out its activities. This is so that no function takes control of the process. If that happens there is a danger that tasks and requirements outside that function are neglected or not allocated the time and the importance they deserve. Finally, if no process is in place there is no control over the activities carried out and time is wasted deciding whether the required output has been met for a specific task and what is the next step to be followed.

After these initial activities, guidelines, and scene setting the task force began the development of the process.

10.2.2.2 The NPI process

After a considerable amount of time and effort, approximately 12 months, the task force came forward with the following proposal.

The New Product Introduction model process was made up of seven distinct phases that deal with:

- Market opportunities – capture, content, and assessment.
- Market evaluation – customer current and future needs projection and feedback.
- Concept phase – product ideas.

- Product plan – product and process technology selection and development, final product definition, and project targets.
- Development phase – product design and evaluation, and manufacturing system design.
- Production phase – product manufacture, delivery, and use of the product.
- Support phase – product support, user feedback.

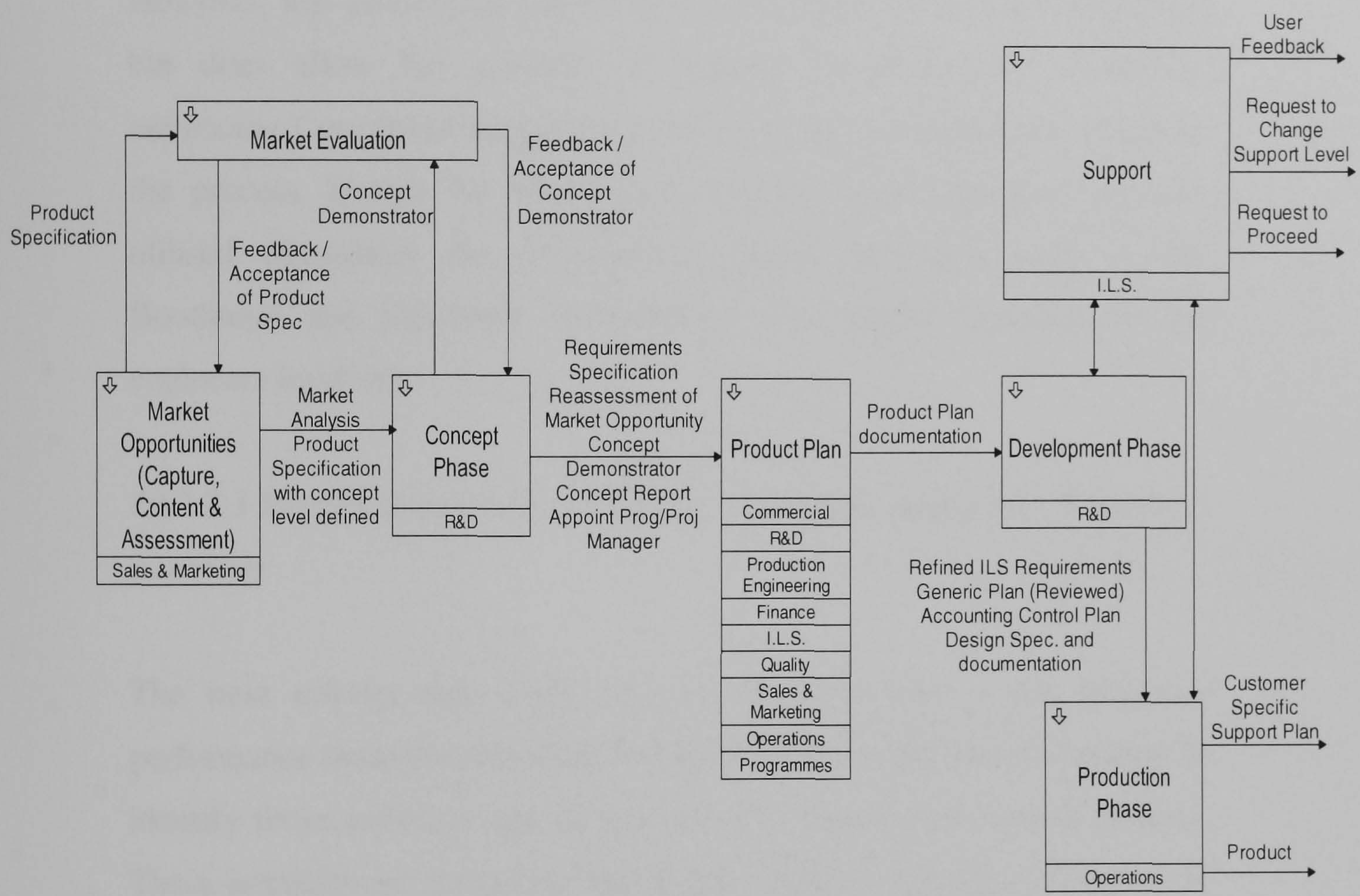


***Figure 10.1** Detailed High Level NPI Process*

Details of the expanded process is attached in Appendix 8.

Typically, a process like this is expected to take up to 2 years in the market that the company targets. The first stages of the process that incorporate Market Opportunities, the Concept Phase and the Market Evaluation phase could take anything between 2 weeks to 6 months depending upon the detail that the customer may require. The second stage of the Product Plan and the Development phase usually takes 2 years. Finally, the Production phase due to the lead-time of most of the company's products takes roughly 6 months to complete. The last phase, which is the Support one, could take up to 15 years according to some existing contracts.

However, this process, as can be seen from figure 10.1, is not sequential but does allow for activities to happen simultaneously. Therefore, embracing Concurrent Engineering practices and shortening the length of the process. Design for Manufacture methods and techniques are also utilised throughout the Development phase and tools such as the Boothroyd and Dewhurst methodology were highly favoured by the engineers involved.

10.2.2.3 Identification of Value Added – Non Value Added and Wasteful Activities

The next activity that forms part of the first step of the proposed performance measurement methodology is to review the process defined to identify those activities that do not add any value in the overall process. These activities are classed as Non Value Added or Wasteful activities. In order to carry out this task the team identified a product (Product X) that had followed the formal documented process described in Appendix 7 for review. Value Stream Mapping (VSM) was the method chosen to map the activities and any communication and document routes of this product's life cycle.

It was evident from the state of the VSM map that although a NPI process was in place the activities carried out on the development of this product were not as well co-ordinated, clear and well defined. The VSM map was transferred in excel to produce a graphical representation of a map that was drawn on a big board with post-it notes and different colours of string that linked each step.

Each process step was also analysed in detail in order to identify the non-value adding and wasteful activities incorporated. From this analysis the team concluded that all those involved in the NPI process of Product X spent most of their time in non-value adding activities. By reviewing the pie chart in figure 10.2 it can been seen that only 0.76% of the activities carried out can be classed as Operations or otherwise known as Value Adding activities.

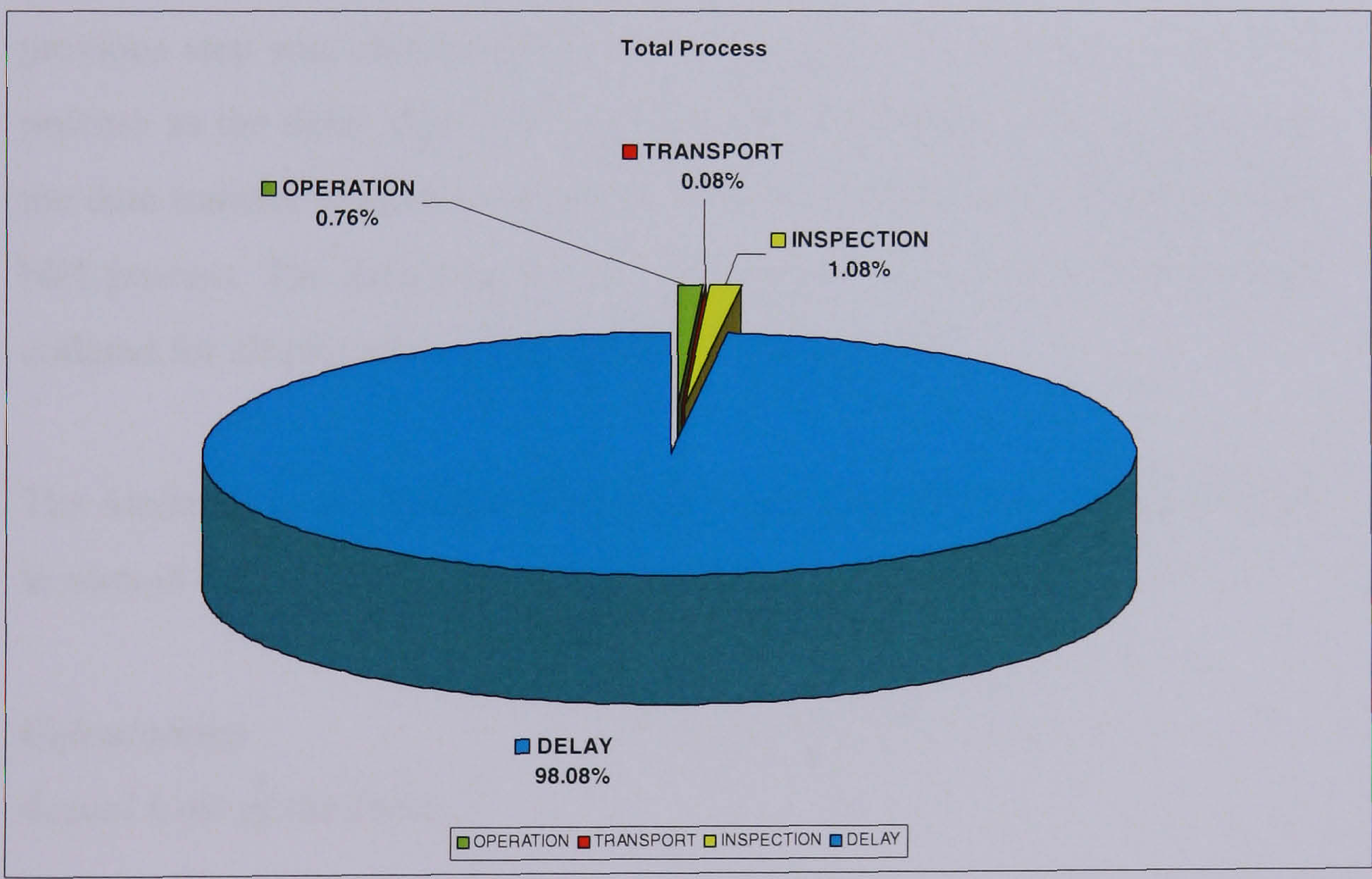


***Figure 10.2** Results of VSM Activity*

From the results of this activity it was evident to the team that having a well-defined NPI process is not the only prerequisite of an efficient process.

10.2.3 Step 2: The Value Indicators

The next step in the methodology is to collate key data from the development process. This data can be entered on the value indicator formula developed for the practitioners to identify the percentage of loss that has or can occur, depending at which stage of NPI process the data refers to. The data required was obtained throughout the duration of the case study whilst concentrating on a particular product development and introduction project.

One of the non-value adding activities that were identified from the previous step was chosen due to the disruption it was causing to the NPI process as the delay that was to be investigated further. This activity was the data transfer from the engineering to the manufacturing function in the NPI process. The data used for the calculations below represents the data collated for all projects carried out in a financial year.

The formulas to be used for the calculations have been described in detail in section 8.4.

Calculations

Actual Cost of the Delay

- Costs occurred due to the Data manipulation. The engineering function produces a set of data called a "data pack" which consists of the design and specification of the new product. The manufacturing department received this data pack. Upon receipt the manufacturing function needs to modify the data back to fit the manufacturing and purchasing processes. To complete a data pack translation it takes one person at a full time basis 2 weeks to manipulate. The total number of data packs that are released a year are about 8. The internal rate for the function carrying out this activity is £46 per hour.

2weeks x 5days/week = 10 days

10days x 8hours/day = 80 hours

80hours x £46per hour = £3,680 per data pack

£3,680 x 8data packs/year = **£29,440 per year**

- Significant engineering changes take 1 week to manipulate and are about 100 such changes each year it takes one person full time.

1week x 5days/week = 5days

5days x 8hours/day = 40 hours

40hours x £46per hour = £1,840 per change

£1,840 per change x 100 times/year = **£184,000 per year**

- Minor changes are not as time consuming. Allowances have been made in the significant changes in terms of time and quantity to compensate the absence of minor changes calculations.

Actual Cost of Data Manipulation = £214,000 per year

Actual Costs due to Penalties

- Penalties from delayed deliveries. The company receives 10 orders a week therefore 480 orders a year. The sales turnover per year is £50M, therefore, the average order price is £104,200. From the company records it can be seen that 30% of the orders include penalties on the contract. This in effect means that 15 orders could be affected. The penalties are typically 1% of the order value. This calculates a loss of £1,042 per order. From the company records it was identified that 6 orders were late, accumulating a loss of £6,252.

According to the previous calculation the problem attributes to 12.5% of the total time therefore,

Actual Attributed Cost to the Penalties = £780 per year

Potential Costs

- Lost orders due to long time to market. On average the company receives 20 quotations every week, therefore,

  20quotations x 48weeks = 960quotations per year

  A number of those quotations are lost, estimated to 7% due to the length of time to market. This makes the number of lost quotes to 67. The average price per quotation is £100,000 therefore

Potential Order Loss = **£6,700,000 per year**

It has been estimated that the delay targeted contributes approximately to 12.5% of the time quoted (based on a typical quote of 6 months = 24 weeks and 3 weeks taken for "data pack" manipulation and a few subsequent changes).

Price Reduction

- The company does not reduce its sales price to compensate for the time the product takes to reach their market. Therefore, this part of the indicator does not apply in this case.

Therefore:

Potential Attributed Cost to the Problem = £837,500 per year

SUMMARY

TOTAL ACTUAL COST = £213,440

TOTAL POTENTIAL COST = £838,281

ESTIMATED TOTAL COST = £1,050,000

POTENTIAL LOSS = 2.1%

This could represent an approximately 2.1% loss based on the £50M sales turnover that could easily if eliminated become a percentage of profit.

The same process was followed for other issues identified throughout the process providing a loss percentage that can be attributed to each individual delay. The data from the issues studied will be used for the Qualitative Analysis detailed in section 10.2.5.

10.2.4 Step 3: Problem Solving

The delay that was identified from step 2 was also used in this step of the methodology. The purpose of this step is to identify potential solutions to the problem. The problem solving method used in this case was the Soft Systems Methodology (SSM) that has been described in chapter 8. The following documents the application of the SSM by the project team.

10.2.4.1 Step 1: Define the problem

The NPI process is a very information intensive process. As the amount of information in the process increases, design time grows and the ability to effectively utilise information becomes more difficult. There is an enormous flow of information between different specialists that are involved during the NPI. Each of these functional specialists most definitely has a view of the product information that stems from their domain of expertise. These differences in the representation of product data can cause a number of problems. Ideally, and in order to serve the concurrent model, it is preferable to have a single product information model that all parties can have access to. The author argues and literature supports (Calabrese, 1999) that information produced during the development process is often incomplete, irrelevant, incomprehensible, and occasionally even incorrect. Different functional areas have different perspectives, use different frames of reference and languages. This requires a considerable amount of time for needles, but under current circumstances necessary, translations of the engineering data set to a production data set that is relevant to the manufacturing group. The identified requirements from the industry focus on the following: consistency and flow of information, rapid and better product data, access to high quality information, and improvement to the design-manufacturing integration. These issues have been attacked from a number of perspectives over the years. Considerable progress has been made, but still these issues exist. This is because they are extensive, ill defined and need to be dealt with at different levels within the organisation.

10.2.4.2 Step 2: Rich Picture

The problem situation can be expressed as a "rich picture". The process involved is to represent pictorially all the relevant information and relationships. The rich picture is a way of consolidating the understanding of the problem situation. This reduces the possibility of opposing perceptions of the real world hindering the modelling process later on.

10.2.4.3 Step 3: Root Definition

It is important that attention is paid to the development of root definitions. Properly written root definitions provide a much simpler insight into building system models. A root definition is expressed as a transformation process that takes some entity as input, changes or transforms that entity, and produces a new form of the entity as output.

The root definition in this case is as follows:

"There exists a need for formulation of a robust design information system to produce accurate and correct information on a timely manner. This information will be generated and owned by the engineering department, and it will be in the predetermined format required by the recipient, in this case the manufacturing function, for immediate use."

Part of the problem expression is working out who are the involved parties. Checkland uses mnemonic CATWOE to describe the human activity and its situation.

C: customer (people affected by the system, beneficiaries or victims);
A: actor (people participating in the system);
T: transformation (the core of the root definition - the transformation carried out by the system);
W: *Weltanschauung* (German word which roughly translates to "world view");
O: ownership (the persons with the authority to decide on the future of the system);
E: environment (the wider system)

The CATWOE mnemonic can be used as a checklist to ensure that the root definition is complete. The CATWOE for this case is as follows.
C: manufacturing function
A: design engineering function
T: need for an improved information and information flow from the design process

W: the new process will substantially reduce time-to-market, which is very important when introducing new products

O: design engineering function

E: existing processes and current culture

10.2.4.4 Step 4: Conceptual Models

The following conceptual model (figure 10.3) was developed by the author to overcome the problem situation defined through steps 1 - 3. The method described could resolve the main issue related to the delayed release of information to manufacturing, from engineering.

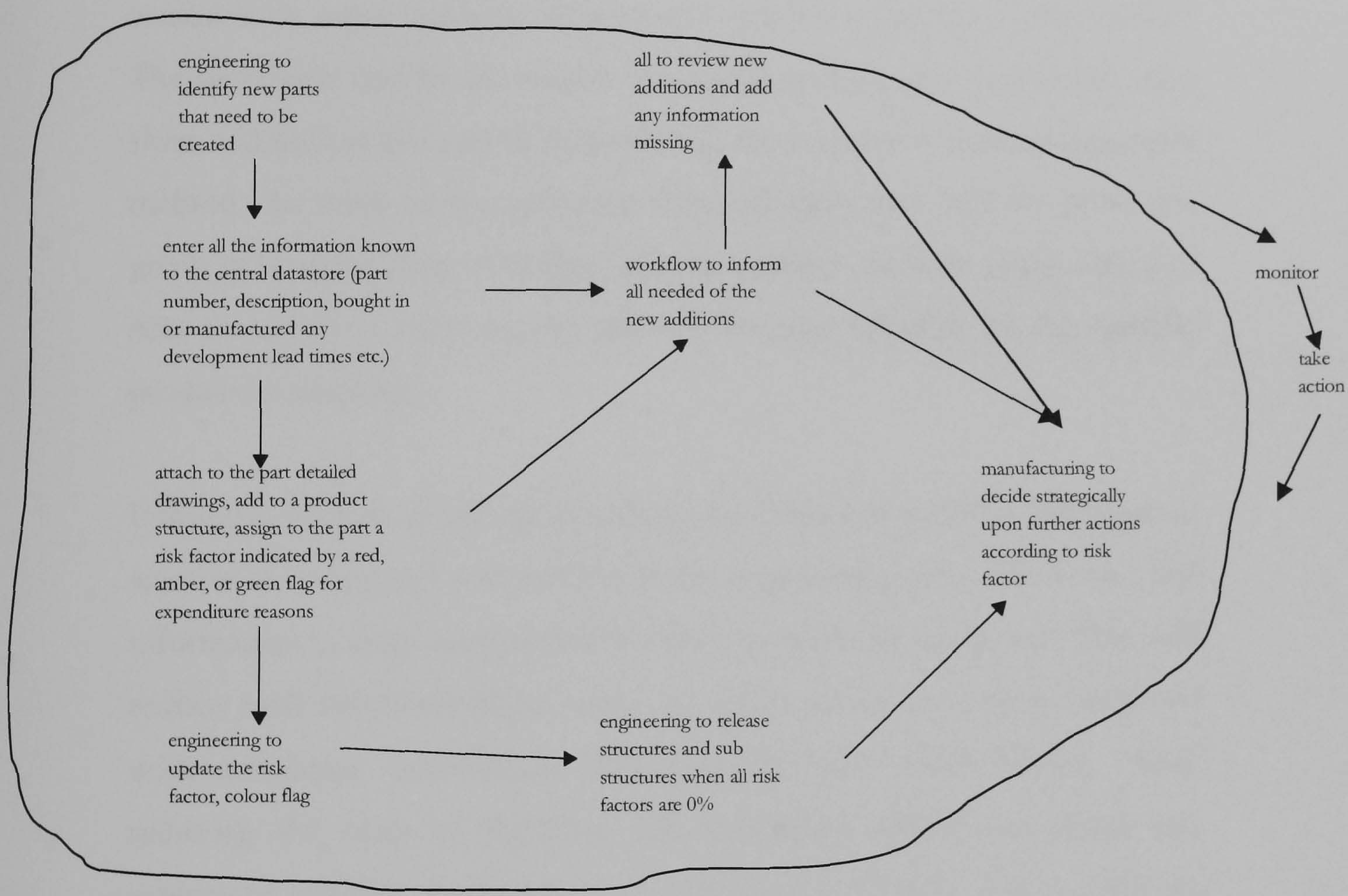


***Figure 10.3** SSM Conceptual Model for this problem*

Colours could be used to indicate the risk involved in using a part rather than a percentage as a risk factor, on the electronic part number database. Red can be used for parts not to be used by production or others except engineering. Amber, for parts that are still under development but production can access the business risks of activating them early (e.g. for parts with long lead time there might be a conscious decision to purchase despite the risk of change). Green items will be those that can be widely used by all.

Any changes to the established design can be introduced by using the above system and to implement the facility of the effectivity date, readily available in most business information systems currently in the market. The new parts can be developed in parallel to the parts used in the shop floor and their status can be indicated by the coloured visual management method. As soon as the parts are finalised then they will be given the green indication along with their effectivity date. As soon as the effective date for a part is released, the old will become obsolete for the specific product or assembly.

Using this system, information will be available and useful to everyone as soon as it is realised and drafted in the engineering area. However, this information is also safeguarded in order to avoid its hasty use. This will reduce total time-to-market, since the parts can be reviewed, enhanced with additional information and potential used much earlier, while reducing the costs of handling and translating information from one system to another. Information now becomes dynamic and is used on Just-in-Time basis.

After Company "A" went live with a new ERP system that was to hold all the data for the parts used in the design and manufacturing process, the concept discussed here was modified to fit the capability of the system. Instead of colours, a status was used to indicate the risk involved in using a particular part. The three stages used were: Preliminary (to represent the red colour); Active (to represent the amber colour); and Released (to represent the green colour).

10.2.4.5 Step 5: Comparison

A matrix is used for comparing the conceptual model with the real world situation. The results are as follows:

Table 10.1. Comparison Matrix

ACTIVITY	EXISTS (Yes/No)	HOW IS IT DONE?	HOW IS IT JUDGED?	COMMENTS
1. engineering to identify new parts	YES	After the concept phase the engineers define the parts in detail	GOOD	The existing process of the development phase caters for this step
2. enter all information to the datastore	NO			Information is in the designer's head, PC, or paper. There is no flow of information at this point and nobody else knows what is happening
3. inform all of the additions	NO			Interested parties do not get involved until the call of the first project meeting
4. review information	YES	Internal communication , usually in the	GOOD IN GENERAL	This activity comes with all the shortfalls of the cross-functional team e.g. co-

		form of project meetings		ordination and control
5. add information	YES	After project meetings additions are incorporated to the drawings	GOOD IN GENERAL	This stage relies upon the integrity and availability of the designer involved to carry out the changes or additions
6. colour code parts	NO			This activity will give the advantage of using the correct piece of information for business decisions
7. release design	YES	After the Final Design Review the design is widely released	GOOD IN GENERAL	Currently, the release of designs takes place when all design activities are stopped and the design is "frozen". However, advanced planning and scheduling would be more beneficial. Drip feed of the design information will give an advantage to manufacturing in terms of planning
8. manufacturing decisions	YES	Manufacturing decisions are taken with limited information. Not a formal process	BAD	Decisions are made poorly with no valid information. This is very risky and will eventually lead to significant losses

10.2.4.6 Steps 6-7: Actions

At this point desirable changes need to be agreed. These changes will move towards the ideal system. Finally, the agreed changes need to be implemented. The SSM exercise has indicated the following:

- The Data Transfer issue can be solved by proving an electronic workflow system or have regular meeting with all affected
- The Complex process can be solved by re-engineering the process internally or by employing consultants
- The Lack of Project Management skills can be resolved by training the relevant people or by employing Project Managers
- The Design Change process can be improved by re-engineering internally or by consultants

In order to identify an activity plan that would fulfil the identified solutions step 4 of the performance measurement method needs to take place.

10.2.5 Step 4: Qualitative Analysis

The following summarises what was achieved by following the steps of the proposed methodology:

Through Step 1: The NPI process was fully documented and process mapped and the following issues were identified.

- Data Transfer between Engineering and Manufacturing was very time consuming.
- The NPI process was too complex.
- Lack of Project Management knowledge.
- Design Change process too long.

Through Step 2: The value indicators described in section 8.4 have been applied for the issues identified providing the following results based on data provided by the commercial and engineering managers:

- Factor 1: Data Transfer effects the Sales Turnover by 2.1%.
- Factor 2: Complexity of the process effects the Sales Turnover by 1.25%.
- Factor 3: Lack of Project Management skills effects the Sales Turnover by 1%.
- Factor 4: Length of Design Changes process effect 0.75%.

Through Step 3: The problem solving exercise showed that the above factors (1 – 4) could be solved by:

- Solution 1a: The Data Transfer issue can be solved by proving an electronic workflow system; or
- Solution 1b: by having regular meeting with all those affected.
- Solution 2a: The complexity of the process can be solved by re-engineering the process internally; or
- Solution 2b: by employing consultants to assist in the re-engineering activity.
- Solution 3a: The Lack of Project Management skills can be resolved by training the relevant people; or
- Solution 3b: by employing Project Managers.
- Solution 4a: The Design Change process can be improved by re-engineering utilising internal resources; or
- Solution 4b: by consultants.

At step 4, time and cost factors need to be applied to the data gathered in order for the qualitative analysis to take place. By applying these time and cost factors the results from the previous step the following data becomes available.

TIME

The time values are either actual or an estimate as indicated below.

- Solution 2a - to simplify the NPI process internally it will take - **18 months** (actual)
- Solution 4a - to improve the Change management process internally it will take - **8 months** (actual)
- Solution 1a - to introduce a workflow system it will take - **6 months** (estimate)
- Solution 3a - to train people at a competent level on project management it will take - **3 months** (actual)
- Solution 2b - to simplify the NPI process with consultants it will take - **2 months** (actual)
- Solution 3b - to employ Project Managers it will take - **2 months** (actual)
- Solution 4b - to improve the Change management process with consultants it will take - **1 month** (actual)
- 1b - to arrange regular meeting it will take - **2 days** (actual)

COST

The cost values are either actual or an estimate as indicated below.

- Solution 3b - to employ Project Managers x 5 (according to the needs of the company at the time a number of 5 Project Managers was identified) it will cost - **£150,000** (actual - according to annual average for the company for that role in 2003)

- Solution 1a - to introduce workflow software it will cost - **£50,000** (estimate)
- Solution 1b - to arrange regular and attend those meetings it will cost (12 people 4 hours per week)- **£25,000** (actual)
- Solution 2a - to simplify the NPI process internally (10 people, 3 hours a week, for 18 months, on £25 average) it will cost - **£23,000** (actual)
- Solution 3a - to train people on project management (5 people, 1 day a week, for 3 months) it will cost - **£12,000** (actual)

- Solution 4a - to improve the change management process internally (3 people, 3 hours a week, for 8 months) it will cost - **£7,000** (estimate)
- Solution 2b - to simplify the NPI process using consultants it will cost - **£10,000** (estimate)
- Solution 4b - to improve the change management process using consultants it will cost - **£5,000** (estimate)

By plotting the data identified above for each factor the following qualitative matrix can be generated, as illustrated in figure 10.4.

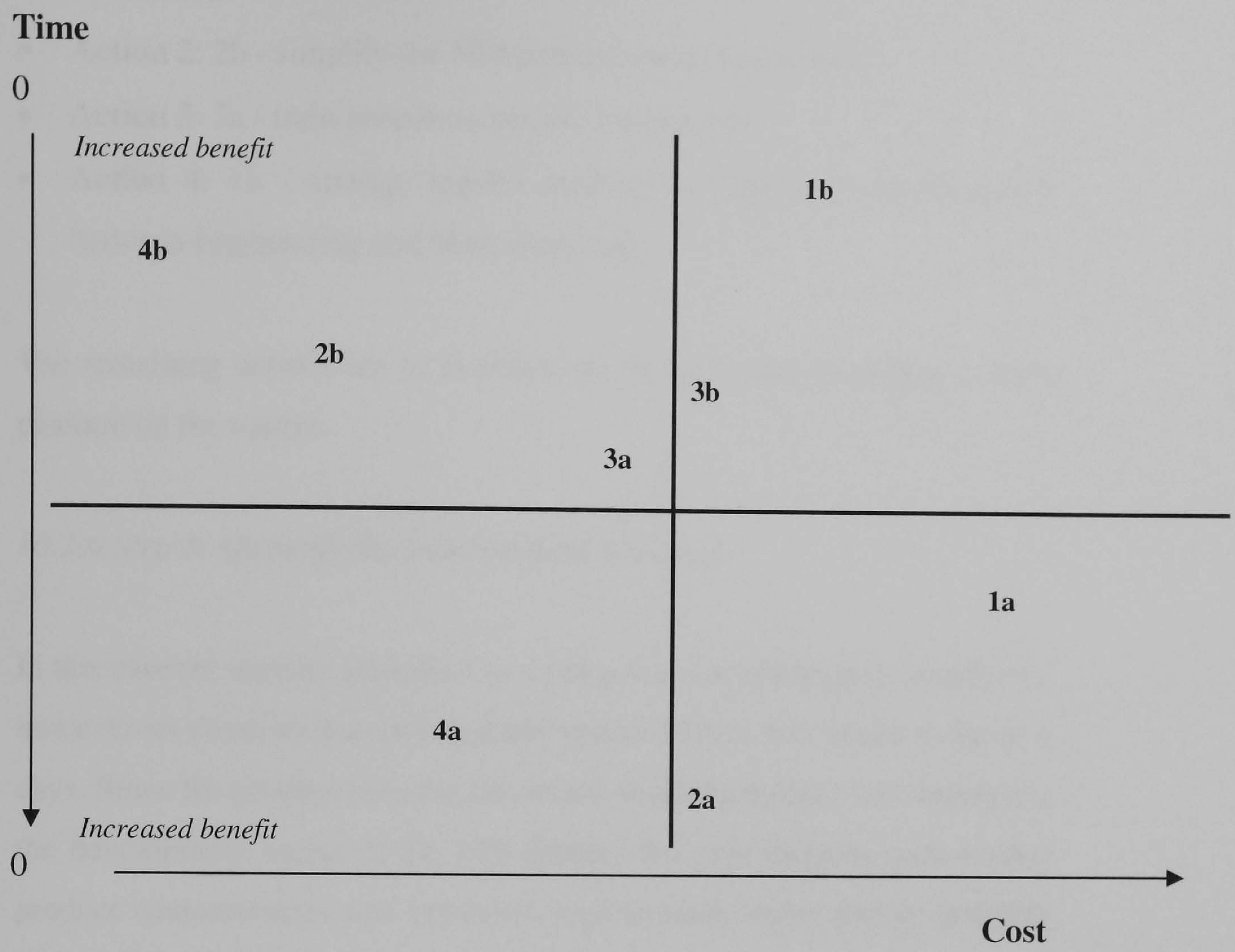


Figure 10.4 *The Qualitative Matrix for the delays reviewed*

The target is to resolve the issues that will yield the highest benefit using the most efficient way. For Company A the most important factor at the time of the exercise was costs therefore, solutions that fall into the Low Cost and Short/Long Time Taken where preferred. By observing the matrix above it can be seen at a glance that the issues that fall on the *Increased Benefit* quartiles with the highest factor will produce the highest reduction on the process costs.

Therefore, the priority action plan in this case will look like this:

- **Action 1**: 4b - improve the change management process using consultants.
- **Action 2**: 2b - simplify the NPI process using consultants.
- **Action 3**: 3a - train people on project management.
- **Action 4**: 1b - arrange regular meeting to improve communication between Engineering and Manufacturing.

The remaining actions are to populate the project plan according to their position on the matrix.

10.2.6 Step 5: Quantify the improvement achieved

In this case the activity identified as a delay was not eliminated completely, however its duration was substantially reduced from two weeks to up to 4 days. Since the product selected for review in the first place had undergone the development stages of the NPI process the next projects with similar product characteristics and customer requirements were used to quantify the improvement achieved.

The delay was reduced in time after this improvement initiative as well as due to a new business system that was implemented in the subsequent months after this exercise. A number of actions on the plan were also completed. The new system however, caused the team to rethink their original plan and re-arrange some of the initially proposed and implemented activities. A new NPI process was put into place to incorporate these changes.

In order to assess the performance of the new process the second step of the methodology proposed by the author was followed. The next product introduced with similar characteristics and attributes to that used for the case study, the value indicator from step 2. In this case engineering generated the required data on the ERP system. The data was set by the engineers to preliminary, active or released according to its completeness. The manufacturing function was then able to review this data and use it accordingly. This reduced the time that the data used to take to be transferred from one department to the other whilst indicating which item of data was ready for use and which required further work and at which area.

Using the new process data collected throughout this NPI activity the new total costs were calculated to be approximately £1M. This figure can be translated to a 1.99 % loss. This is an improvement of 0.11% compared to the original value (section 10.2.3). This 0.11 % was the net effect of the team concentrating on one delay only. A larger improvement would be identified if all of the delays identified were to be addressed.

10.3 Conclusions

This chapter has covered the application of the performance measurement method proposed for the NPI process in a company case study. All of the steps of the method were executed without any major issues. The fact that the team involved had the necessary skills and knowledge to see this project through was a key factor to this success. It is therefore necessary to make sure that the correct people are involved in this type of activities.

One aspect of the project that was not particularly commendable was the amount of time it took for the team to go through certain steps of the process. Step 1 the process mapping exercise and Step 3 the problem solving activity took most of the 18 months that were spent as a total on this project.

However, this case study has shown that the methodology developed by the author could be applied during or at the end of a NPI process to identify, quantify and resolve any delays encountered.

In this particular case, company A fell into the category of a company that did not have a well-defined NPI process. By following the 1^{st} step of the methodology (process mapping), the company was able to document what the process was as well as identifying its shortfalls/delays. These shortfalls were not dissimilar to those that other companies encounter and have been listed in section 2.3.2. Using the 2^{nd} step of the methodology (value indicators) the team was able to quantify the effect of the particular delay in question. The 3^{rd} step (problem solving), proposed a new to the company problem solving technique that provided focus and resulted in a number of solutions for the particular problem that caused the delay. The 4^{th} step (the matrix), prioritised those solutions based on the effort and resources –people, cost and time – required. By doing so the team was able to select the solution that had the potential to produce the best results in this particular case. Finally, the 5^{th} step of the methodology (the results) quantified the results of the corrective action that illustrated to management the benefits gained by the application of this methodology.

In this case study, the application of the methodology was successful and yielded the results expected by the author based on the multi-level analysis that was carried out on section 9.4.1. According to company's "A" characteristics - medium sales turnover, some order loss due to the length of time-to-market, no price reduction due to order loss, variable order intake and compensation offered to customers for late deliveries – and the results of the multi-level analysis that are summarised on table 9.1, the effect of the NPI process delays is expected to be high. The review of a single delay of just 2 weeks resulted on a 2.1% loss based on the value indicators. This figure could be extrapolated if all the delays in the process were to be addressed.

11. CONCLUSIONS

11.1 Introduction

This thesis explored the scope of the application of a performance measurement method to support the New Product Introduction process. In doing so it brought together the fields of Performance Measurement and NPI. Both subjects have their own literature and research activity, however, they had previously remained separate.

As detailed in the introductory chapter the aims, objectives and the key questions concerning this research where:

- Aim: to determine the extent, in terms of both theory and practice, to which a performance measurement method specifically developed for the NPI process can be utilised to monitor the process and subsequently increase company profitability.

- Objectives: establish a methodology to enable practitioners to monitor and measure the performance of the NPI process; and determine the value indicators that would be used to assess the performance of the NPI process; and identify different company characteristics that may influence the application of the method proposed.

- Key Questions: Q1: To what extent is performance measurement being applied within the NPI process; and Q2: To what extent could performance measurements be applied within the NPI process

By reviewing the chapters in this thesis it can be seen that these aims, objectives and key questions have been addressed. The findings proved that performance measurement is not extensively applied within the NPI process. The measures currently used tend to be applied at the end of process providing little useful information and direction for improvement. Regarding the research objectives set and specifically Q2, a performance measurement method that addresses the needs of the NPI process was developed and its validity was proved by the various methodologies that were utilised (mainly the postal survey and the case study). Therefore, this research project has satisfied its aims and objectives by developing a performance measurement method that would be applied within the NPI process both as a static and predictive indication of the performance of the process.

In detail, an investigation into the current context of NPI was undertaken obtaining evidence of the need for organisations to improve their NPI process in order to remain competitive. The chapter following that introduction described the concept of Performance Measurement in general. Chapter 4 reviewed and 5 summarised the current practices of performance measurement within the NPI process and identified the need for further research in this area. Having argued for the introduction of a method to measure the performance within the NPI process in theory, the following chapters introduced the method developed to investigate performance measurement within NPI in practice.

Chapter 6 stated the rationale for following the approach chosen for this research. It then described the research strategy and showed how the initial investigation led to the application of multiple methods. Hypothesis generating workshops took place early on in the project, a postal survey followed, interviews then took place to verify and validate the data provided by selected survey respondents and finally the detailed study provided validation of the proposals made. A critical review of the methodology applied concluded that although the methods chosen had certain limitations, their degree of validity and reliability was such that it was possible to build an accurate picture of the application of the performance measurement method to the NPI process. The findings from each of the research activities were reported in Chapter 7. Chapter 8 described the performance measurement method proposed to support the NPI process. All the steps of the process were explained in detail. The second step of the methodology is based on a value indicator that was specifically developed by the author to cater for the needs of the NPI process. The suitability and applicability of this indicator was discussed in Chapter 9. The fourth step of the methodology, the qualitative matrix, was also developed by the author to provide a tool of prioritising corrective action to maximise process cost reduction. Chapter 10 introduced a case study in which all of the steps of the methodology were carried out in a case company. The method was successfully implemented and the expected results were recorded.

11.2 Summary of Findings

The arguments and evidence presented in this thesis lead to the following conclusions:

- The application of the Performance Measurement Method for the NPI process described in this thesis is appropriate both in theory and in practice, though companies may find it hard to move from theory to practice due to Change Management concerns.

- The scope for applying the Performance Measurement Method within NPI appears to be broad. The method can be applied in a wide variety of companies, regardless of size, industry sector, technology and type of product. However, there are some characteristics (such as overall turnover, level of competition and order intake magnitude) that limit the benefits of the application of the method.

- The framework of the method is useful in providing direction, describing and explaining the performance measurement process within the context of NPI.

A company would benefit by incorporating such a performance measurement method as part of the standard procedures and business management routines. All those involved in the NPI process should be introduced to the method as well as the preferred templates and documentation that the company has decided on for the presentation of the results. Such a method should form a holistic approach. Although this method could be carried out on an ad hoc basis this is not the expectation of the author. The benefits of its application of the method would be far greater if it was performed on an ongoing basis as part of a formal NPI process.

The validation testing through the research methods followed were largely supportive of these conclusions. However, due to the nature of this research project it was not possible to fully address the validity of the method in a comparable scenario or case study. This has opened up further avenues of debate and areas, which would benefit from further work. In an ideal world of research, one would like to collate data simply to illustrate the power and value of the designed indicators without any corrective actions and then repeat the same experiment with corresponding actions to illustrate improvements.

The framework of the performance measurement method within the NPI provides the means to describe and explain performance measurement within a company's product development environment. However, one of the benefits of the method is that it also has predictive powers if used during the life of a project. Further research could explore the results of the method when used in such an activity.

Finally, the method of performance measurement presented in this thesis is open to challenge. Both the method and the indicators proposed may be improved to account for new methodologies and emerging company characteristics.

11.3 Future Research

Although the aims and objectives concerning this research have been met and the research questions have been successfully answered, the author discovered a number of areas that could merit further investigation. Some of them were mentioned in the section above. All of them are summarised here.

Further case work might focus on the "softer" issues that are involved with the application of the method. The research can take the form of observation and action research. Interview, observation and documentation could provide valuable data. The focus would be on the behaviours necessary for the successful implementation of the performance measurement method. The applicability of the method to different stages of the NPI process as well as the impact of applying the method could also be reviewed. Meanwhile, action research could take place in organisations that are experiencing difficulties in implementing such a method within NPI. This research would overcome the barriers of performance measurement within NPI and would introduce effective enablers for the implementation of such a method.

Another postal survey could be used to research further into the extent of the practice of the method when taking into account variables such as product complexity, frequency of new product launches, product life cycle, organisation structure, and size of development organisation. The results from such a survey could be correlated with the results presented in this thesis for a relationship graph to be developed between company characteristics and benefits to be realised by the use of the method. This could aid practitioners in deciding whether this method is appropriate for their company specifics.

A case study could also take place to validate the value indicator proposed in the second step of the performance measurement method. By using the value indicator described in the method the losses that would occur can be calculated under the current processes for a chosen product. The key in this study would be not to make any changes to the normal processes, follow the process through while collecting data on the delays and entering it to the value indicator calculation. At the end of the process the predicted loss calculated by the indicator can be compared with the actual loss from the delays throughout the process. Although this might prove extremely difficult to undertake, it would add to the validity of the model.

Finally, a study could take place to review the application of the method during the lifecycle of a new product introduction project. The method and indicators in particular could be used from the very outset of a new programme. Every time a delay occurs the indicators would produce a predictive figure of loss. The practitioners then would be able to decide how the project can be rectified to compensate for the predicted loss. This could be followed through the whole process assessing the suitability of such a method as a predictor.

The present research has highlighted a number of factors that should be taken into consideration for future research when deciding which companies to approach. These include the:

- rate at which a company develops new products.
- product and development life cycle.
- external involvement in development.

For example, if the rate of introducing new products is very low it might be harder to map the process and to identify changes and improvements between developments. Lengthy cycle times might make it more difficult to gather data on process steps and improvements. In the case of action research it might be more difficult to assess the impact of an intervention, especially if that intervention is designed to facilitate the transfer of learning and process improvement between successive projects. In such cases it might be better for the researcher to focus on particular phases of the NPI process.

Finally, if there is a degree of external involvement in the development of the product, for example customers, suppliers, regulatory agencies, the researcher should allow sufficient time to understand the relationships and to interview the external players.

These factors relate to different aspects of the research. They could affect:

- comparability between cases and the extend to which generalisation may be applied.
- the suitability of a company for a particular strand of research.
- the time required to allow the researcher to gain a full understanding of the product life cycle in a particular organisation.

The companies to be studied would therefore need to be carefully selected and the implementations of the selection taken into account during the planning of the further research.

11.4 Thesis contribution to knowledge

This thesis has contributed to knowledge in two respects.

First, it has explored the application of performance measurement to the process of NPI. This is a combination that was relatively uncharted. It draws a number of conclusions concerning the applicability and scope of performance measurement within NPI and identifies areas of future research.

Second, the thesis has provided a performance measurement method to support the NPI process that incorporates a performance indicator uniquely developed for this process. The concepts in this framework can assist both researchers and practitioners to understand and explain the implication of performance measurement within the NPI context.

APPENDIX 1

Company Information

Company	Name	Title	Name
A	Smiths Detection Watford	Technical Manager	John Brokenshire
		Programme Manager	Rod Wilson
		R&D Manager	Alan Rhodes
		Projects Administrator	Lin Stretton
		Scientific Manager	Alan Brittain
		Scientist	Martin Thomas
		Quality Assurance Engineer	Ashan Jawaid
		Senior Buyer	Michael Hoare
		Planning Manager	David Cartwright
		Integrated Logistics Support	Nic Gurney
		Operations Manager	Paul Williams
B	Smiths Aerospace Cheltenham	Development Manager	Tim Roberts
		Development Engineer	Ian Morgan
		Development Engineer	Jean-Paul Dean
C	Xerox Ltd	Project Leader	Peter Keilty
D	Anritsu Ltd	Business Manager	Peter George
E	BAE Systems	Scientist	R. Madahar
F	Domino UK Ltd	Director of Engineering	Brian Guinee
G	Elster Metering Ltd	Training & Safety Manager	A. Giliberh
H	Oxford Instruments Ltd	Human Resources Manager	K. D. Smith

APPENDIX 2

Questionnaire

2.1 Pre-Ample

The enclosed questionnaire forms part of a research study that analyses the points affecting the New Product Introduction (NPI) process. The research is concerned with how the delays that occur in the NPI process and how they may affect a company's performance.

I would be grateful for your contribution to this important study regarding the points affecting the NPI process by completing the enclosed questionnaire. The questionnaire is undertaken as part of my PhD studies at the University of Hertfordshire that is sponsored by a subsidiary company of the Smiths Group.

Due to the strategic background of this research, the study will benefit from the input of the Engineering Manager or the Sales & Marketing Manager. He or she should be one of the leaders involved in the implementation of new products and services to the market.

This study will be used entirely for academic research purposes. Your answers will be kept confidential, and neither your name, nor the name of your company will be disclosed.

If you would like more information about the study, please do not hesitate to contact: Val Koliza, telephone +44 (0) 1923 658 109, fax +44 (0) 1923 236 381, e-mail: val.koliza@smithsdetection.com

Thank you in advance for your support.

Yours sincerely,

Val Koliza

PhD Research Student

2.2 Questionnaire Instructions

Thank you for agreeing to participate in this New Product Introduction Survey.

The questions in the survey do not ask for any confidential information. You can be assured that the information you provide will remain strictly classified. Your responses will be combined with these of many others and used for statistical analysis. In exchange for this anonymity, we appreciate the sincerity and objectivity of your answers.

Please fill in this questionnaire as completely as possible. You should be able to complete this questionnaire in approximately thirty minutes. When you have completed the survey, please post it back to us using the enclosed self-addressed envelope.

If you would like to receive a report of the final results, you can either e-mail me or include your business card in the return envelope.

Should you have any questions about this document and this research, please do not hesitate to contact me.

Thank you for you support, time and effort.

2.3 2004 New Product Introduction Survey

Section 1: Company Details*

1.1 Company Name:	URL:	
1.2 Address:		
County:	Postcode:	Country:
1.3 Telephone Number:	Fax Number:	
1.4 Contact Name:	Title:	
Tel:	Fax:	e-mail:
* Please provide your business card to skip this section		

1.5 Your company operates in: (please select the appropriate answer ☑)

☐ The UK only ☐ The UK and other countries

☐ Other, please specify ______________________________

1.6 In which industry sector does your company belongs to:

☐ Manufacturing ☐ Services (e.g. consultancy, training)

☐ Other, please specify______________________________

1.7 What are your company's main products or services?

____

1.8 In which of the following industries do your customers belong?

☐ Aerospace ☐ Consumer

☐ Electronics ☐ Automotive

1.9 What is your company's size in number of employees:

☐ 1 – 49 ☐ 50-249 ☐ 250 +

1.10 What percentage of your products are:

Assembled or made to order ....___________%

Standard off the shelf products....................___________%

Engineered to Order (custom made).............___________%

1.11 What is the percentage of standard parts, made-in parts, and subcontract parts:

Standard parts (raw material).....................____________%

Made-in.._____________%

Subcontract......................................_____________%

Total______100____%

1.12 What is the company's turnover?

____

1.13 What quality or other awards has the company obtained?

____

Section 2: New Product Introduction Process

2.1 Which of these statements best describes your company situation with regard to the New Product Introduction (NPI) process:

☐ Your company does not follow a documented NPI process

☐ Your company does follow a documented NPI process

☐ Your company is in the process of developing a NPI process

☐ Your company does not introduce new products or services to the market

2.2 How many stages does your NPI process include:

☐ 1 – 4 ☐ 5 – 9 ☐ 10 -15

2.3 Please give brief description of each stage.

____

____

2.4 What is the average duration your NPI process:

☐ 0 - 6 months ☐ 6 -12 months ☐ 1 - 2 years ☐ 2 years +

2.5 Which of the following are delays identified on your NPI process:

☐ Lack of an established method of communication between the stages of the process

☐ Lack of a formal process to follow

☐ Complicated formal process to follow

☐ Complex product - not easy to follow a formal process

☐ Often changes of customer requirements

☐ Production issues - no Design for Manufacture

☐ Lack of continuity in the process

☐ Lack of knowledge of Project Management techniques

☐ Other delays identified, please specify ________________________________

____

2.6 How long would you say the delays identified extend the length of your NPI process (time-to-market)

☐ ______ days ☐ ______ months ☐ ______ years

Section 3: Company's environment

3.1 Does your company have to compensate your customers for late deliveries?

☐ Yes ☐ No

3.2 If the answer to the above question is ***yes*** then what is the average percentage deducted in relation to the customer order value:

☐ 1 - 5% ☐ 6 - 10% ☐ other, please specify ______________

3.3 What is the average percentage of customer orders being delivered late, on-time, early in the past three years:

Late....... ____________%

On-Time...____________%

Early........____________%

Total......._____100_____%

3.4 Approximately how many potential orders (quotes) do you receive a year:

☐ 0 – 499 ☐ 500 – 1000 ☐ other, please specify ______________

3.5 How many of the potential order do you believe do not materialise due to long delivery deadlines:

☐ 0 – 99 ☐ 100 – 250 ☐ other, please specify ______________

3.6 What is the average value of a potential order?

____

3.7 Does your company reduce the Sales Price for any products or services to compensate any time-to-market delays?

☐ Yes ☐ No

3.8 If **yes** what is the percentage of the reduction over the Sales Price?

☐ 1 - 4% ☐ 5 – 10% ☐ other, please specify ________

3.9 What is the average internal hourly rate for your company?

☐ 20 - 24 pounds ☐ 25 - 30 pounds ☐ other, please specify ________

Section 4: General Comments

Please feel free to add any comments or concerns related to the NPI process, Time-To-Market and delays identified.

Thank you for completing this questionnaire.

Please return the completed document using the envelope supplied or alternatively you can post it back to the following address:

Val Koliza

PhD Research Student

APPENDIX 3

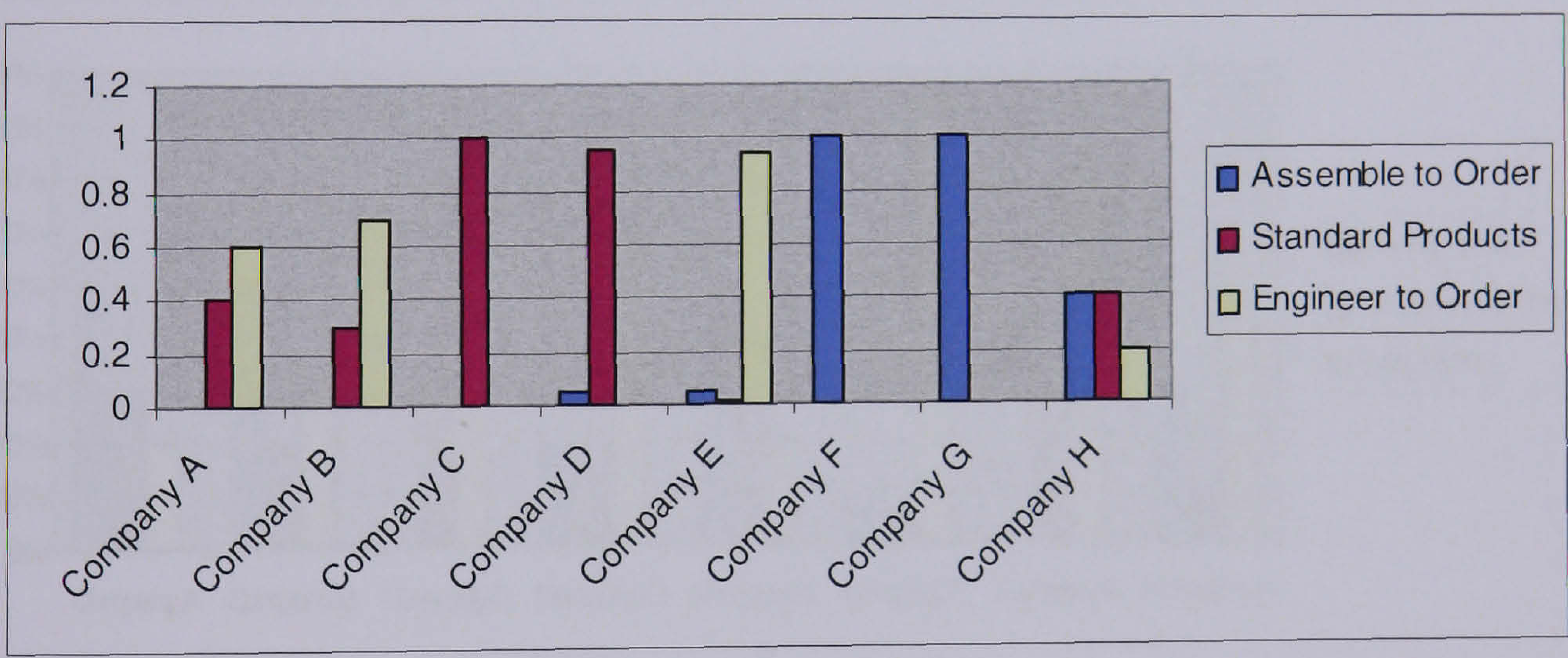
Company Characteristics

Company	*Location*	*Industry Sectors*	*Target Industries*	*No of Employees*
A	UK and Other	Manufacturing	Consumer	250+
B	UK and Other	Manufacturing	Aerospace & Consumer	250+
C	UK and Other	Manufacturing	Aerospace, Electronics & Automotive	250+
D	UK and Other	Manufacturing	Aerospace, Electronics & Automotive	50 - 249
E	UK and Other	Services	Aerospace & Electronics	250+
F	UK and Other	Manufacturing	Consumer, Electronics & Automotive	250+
G	UK and Other	Manufacturing	Consumer	250+
H	UK and Other	Manufacturing	Research	250+

APPENDIX 4

Methods of Manufacture

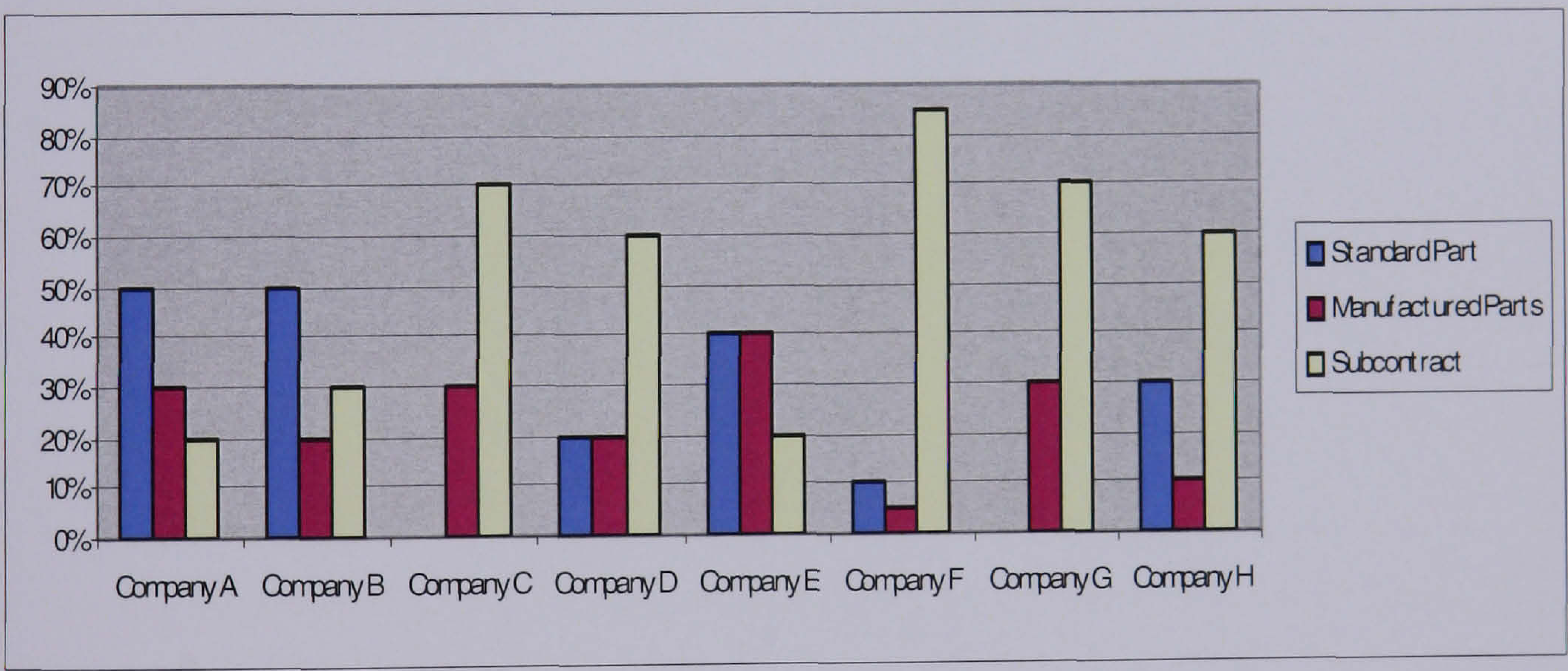
Method of Manuf	*Assemble to Order*	*Standard Products*	*Engineer to Order*
Company A		40%	60%
Company B		30%	70%
Company C		100%	
Company D	5%	95%	
Company E	5%	1%	94%
Company F	100%		
Company G	100%		
Company H	40%	40%	20%



APPENDIX 5

Supply Methods for Material

Supply	*Standard Part*	*Manufactured Parts*	*Subcontract*
Company A	50%	30%	20%
Company B	50%	20%	30%
Company C		30%	70%
Company D	20%	20%	60%
Company E	40%	40%	20%
Company F	10%	5%	85%
Company G		30%	70%
Company H	30%	10%	60%



APPENDIX 6

Reduction in Sales Price due to lateness of entrance to the market

Reduction in Sales Price	*yes*	*no*
Company A		X
Company B		X
Company C		X
Company D		X
Company E		X
Company F		X
Company G		X
Company H	X	

APPENDIX 7

Sample questions for follow-up interviews

- What are the most distinctive characteristics that define your company?
- Do you follow a NPI process?
- What is the typical duration of the NPI process?
- What is the minimum duration and what is the maximum duration?
- What are the typical delays you encounter throughout the NPI process?
- Do you believe that any of these characteristics make you more vulnerable against your competitors when it comes to the timing of the introduction of new products?
- How many new products do you launch every year?
- Does your company have a set of key indicators that assess business performance?
- What are these indicators?
- Do any of these used to assess the performance of the NPI process?
- If a method was available to take through the process of assessing the NPI process will it be of use to your company?
- Would you use such a method as a dynamic/predictive measure or as static?
- Have you got any views as to what needs to be measured?
- Any other comments?

APPENDIX 8

The NPI process for Company A

A8.1 Top Level Process

In figure A8.1 there is a representation of the top level NPI process adopted in Company "A" following a business process improvement initiative. Each sub-process of this top level will be explained in the sub-sections that follow.

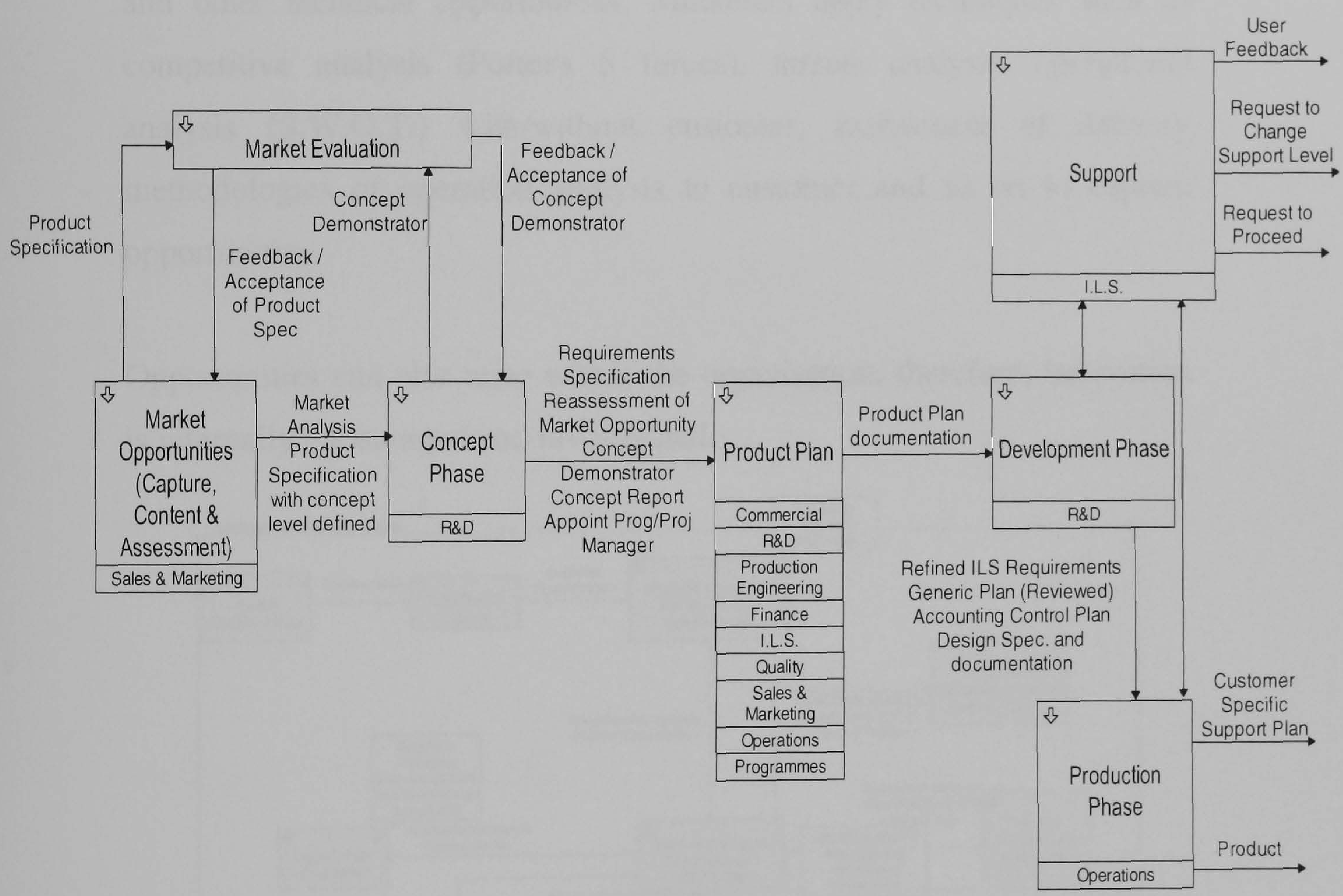


Figure A8.1. Top Level NPI Process

A8.2 Market Opportunities

This is the first stage of the process. At this phase all the possible opportunities that can be identified in the market are collected.

The typical sources of opportunities are dialogue, meetings with customers, competitors information, collaborators information, exhibitions, symposia, or via direct customer enquire. The above methods are usually utilised by the company Sales representative. However, opportunities could also appear through Engineering by bulletins, conferences, government budgets and other technical opportunities. Marketers apply techniques such as competitive analysis (Porter's 5 forces), threats analysis, operational analysis (S.W.O.T.) with/without customer, assessment of delivery methodologies of operation analysis to customer and so on to capture opportunities.

Opportunities can also arise within the organisation; therefore, innovation is internally encouraged and investigated.

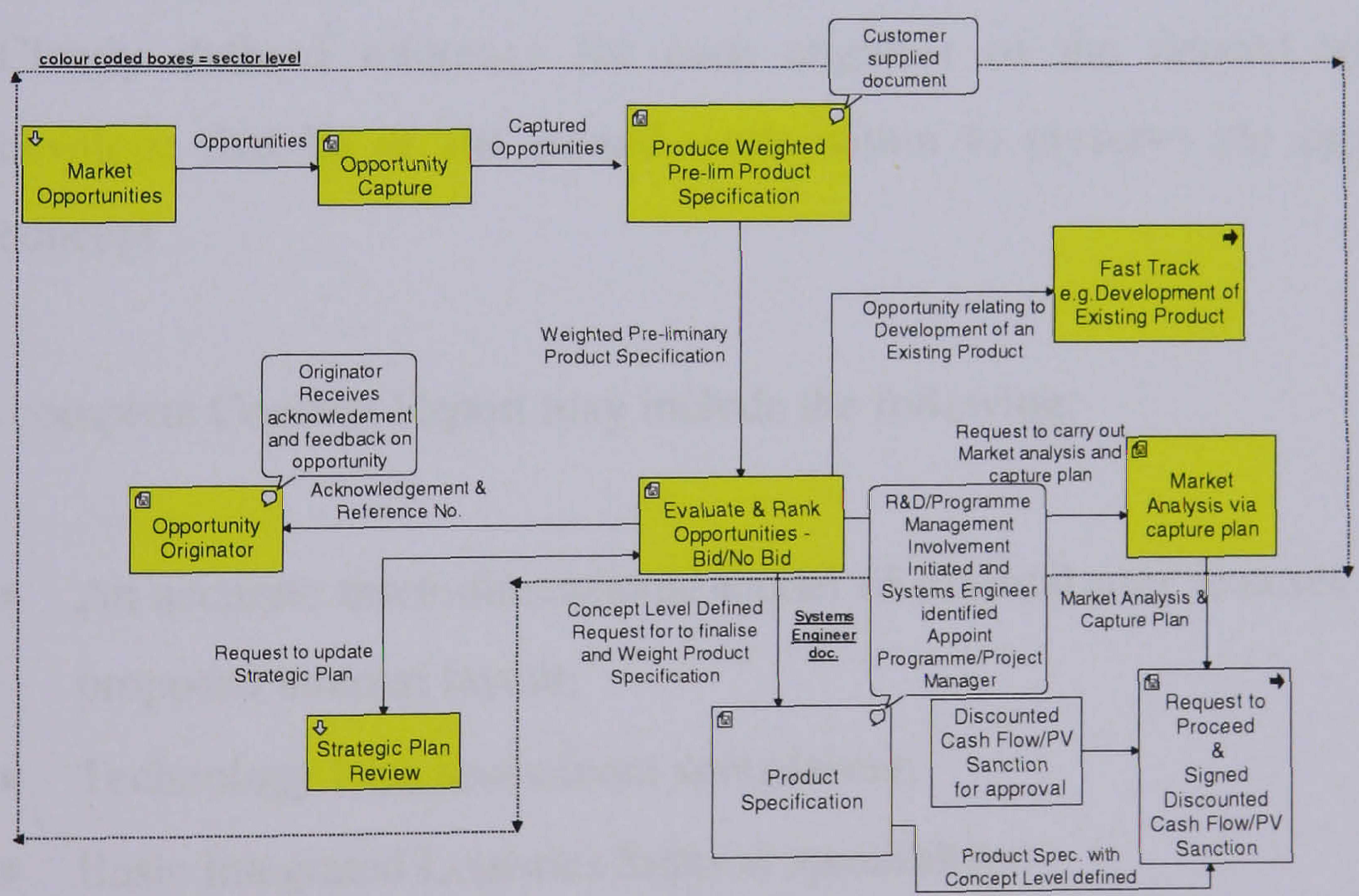


Figure A8.2 Market Opportunities Phase (expanded detail for figure A8.1)

A8.3 Market Evaluation

The purpose of this phase is to generate a report on market feedback on product specification and concepts, as well as reviewing the impact of the feedback on the original opportunity.

A8.4 Concept phase

The purpose of this phase is to provide a focus for the work to be done in the Development Phase. The preferred way of communicating this information is through the Concept Report.

The basis of the Concept Report will usually be a three-dimensional model that clearly communicates the best estimate of both external and internal features of the final product. The benefits of such a report include:

- Clearly identified features and sub-assemblies, which are used as inputs to the planning of engineers' work packages.
- Clearly defined reference for each engineer of the desired space envelope that he or she should work within to preserve the agreed concept.

The complete Concept Report may include the following:

- An accurate three-dimensional model of external user features and proposed internal layout;
- Technology Risk assessment spreadsheet;
- Basic Integrated Logistics Support spreadsheet;
- Human Resource Factors spreadsheet;
- Basic Production Plan;

- Basic Hazard Analysis spreadsheet; and
- Record of the concept selection process.

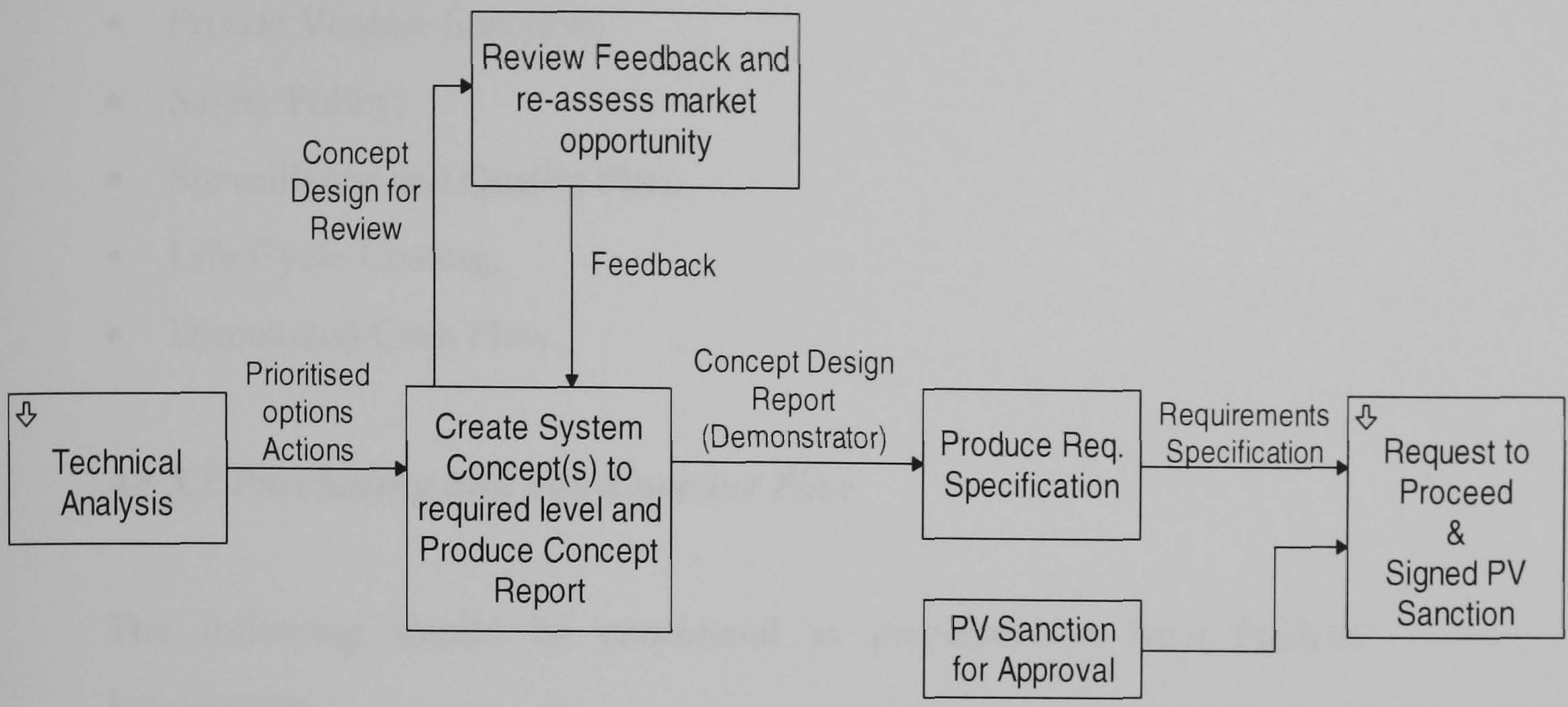


Figure A8.3. *Concept Phase (expanded from figure A8.1)*

A8.5 Product Plan

The following should be prepared and collated as part of the preparation of the Product Plan, prior to the Development Phase:

- Purchasing and Sub-Contract Plan;
- Production Plan;
- Administration Support Plan;
- Accounting Control Plan;
- Commercial Plan;
- Project Plan;
- Concept Phase Report;
- Concept Demonstrator;
- Risk Management Plan and Risk Assessment;
- Obsolescence Management Plan;
- Reliability and Maintainability Plan;

- Draft Integrated Support Plan;
- Requirements Specification;
- Private Venture Sanction;
- Safety Policy;
- Surveillance and Quality Plan;
- Life Cycle Costing;
- Discounted Cash Flow.

A8.5.1 Purchasing and Sub-Contract Plan

The following should be considered as precursors to New Product Introduction.

Make or Buy – the product life cycle should be considered as well as the forecasted quantities.

Supplier selection – initially from the Approved Supplier database, if none in existence then a Supplier Quality Audit should take place to evaluate new suppliers. Sole or single supplier source should also be considered at this point. The different management techniques required to manage either sole or single supplier should be investigated.

Supplier involvement – seek design input from selected suppliers at the earliest stage, a decision has to be taken at this point as to who writes the product specification (supplier, manufacturer, customer, or combination).

Inventory issues – obtain accurate lead-times, ensure costings are within targets, obtain accurate and comprehensive quotations, consider any material handling requirements before detailed negotiations take place, consider how units are delivered and received (e.g. kanbans, packed in units for immediate use, consider re-usable packaging for environmental benefits).

A8.5.2 Production Plan

The following are activities that need to be defined before (where possible), tasked within and supported after the Development Phase.

<u>Planning</u> – time frame and quantities; designed to buy or manufacture, capacity within existing production facility, modifications to existing, new; prime materials; labour built/test hours, work centre targets; non-recurring costs; in-house or bought-out plant, tooling, test equipment, special equipment, material handling.

<u>Involvement</u> – level and stage of production input assistance, transfer and ownership stage, define productions direct and indirect resource input.

<u>Development plans</u> – should include proven tolerances and limits, processing types, materials, inspection levels, test gates, embedded self-test and functional test design and proving.

<u>Supporting needs</u> – core product knowledge should be available at all times, rapid response, planned action, stable built programme, local build standard control within the company, assistance with knowledge transfer and training support, test software and hardware support.

A8.5.3 Administration Support Plan

The Administration Support Plan lists the relevant project meetings and the dates for which they are scheduled. The relevant project meetings are:

- Start of work meeting - launch of the project
- Quality reviews
- Project or progress review meetings
- Risk review meetings
- Production reviews
- Safety review meetings
- Integrated logistics support review meetings
- Critical design review meetings: internal or with the customer
- User working group meetings may include:
    - User review of initial design concepts
    - Intermediate user review of evaluation design
    - Final user review of evaluation design
    - User review of evaluation hardware
    - User review of validation design
    - User review of validation hardware prior to user trials

A statement should be included stating the following:

- Who will host the meetings
- Who will chair the meetings
- Who will provide the minutes for the meetings

When an Administration Support Plan is distributed it should contain:

- An issue number
- A date

In addition to the above any changes made to a previous issue should be indicated in bold.

A8.5.4 Accounting Control Plan

The role of Finance within the NPI process is essentially that of information provision - i.e. to provide data to assess the performance of the various activities involved in production. The following features need to be defined and agreed before (where possible) prior to the Development phase.

<u>Cost Recording Basis</u>: it is assumed the Job Costing is the appropriate cost recording base. Job Costing requires: setting of downstroke (/) structure for cost recording/reporting; estimates/forecasts of costs to be incurred; and it generates: cost/variance data from Job Costing sub-systems.

<u>Measurement Criteria</u>: measures against which cost data can be assessed - (e.g. estimates, forecasts, quotations) - to an appropriate level of detail.

<u>Levels of Detail</u>: using adequate downstroke structure to provide cost monitoring, variance generation. Relate to Work Breakdown Structure as available/appropriate. Awareness of, and allowance for, various cost types.

<u>Reporting</u>: level/frequency of reporting required, and to whom. Report "triggers"

Accountability/Authority: who is responsible for programme. Who has authority to change programme profile, amend programme specifications.
Communication: channels of communication (two-way).

A8.5.5 Commercial Plan

Essential aspects of this report are the following:

- Exploitation Levy (MoD term for exploitation of ideas that weren't initiated in the company): determination as to whether or not commercial exploitation levy is due needs to be identified and logged
- Payment currency: currency will depend on country targeted for sale
- Payment terms: dependant on country of sale. Additional lead-time may be required.
- Export Licensable: ability to be able to market products may impact the design for targeted markets
- Offset: offset obligations will need to be determined. This will be different by country. It is preferable to design in components that can be easily sourced world-wide
- Training: identify training that is likely to be required
- Cost Type: identify the nature of the contract (cost plus or firm priced)
- Law of contract: identify whether the contract is awarded in English or other foreign language
- Liquidated damages: to be determined country by country
- Free issue service of product: control will need to be managed
- Intellectual Property Rights: determination of ownership and exploitation rights

Ideally this report may also include:

- Support costs: benefit of being able to advice the customer of the costs that are likely to occur throughout the product life cycle
- Support logistics: support issues will need to be considered country by country

A8.5.6 Project Plan

The project plan is to be built using the pre-defined company template. This is to ensure that correct structuring, scheduling, and resourcing are used. It will be based on a Work Breakdown Structure that has been derived from an Equipment Breakdown Structure. At this point the project planner has to make sure that the activities described in the plan, when carried out by the appropriate resources, in the specified sequence and at the appropriate time, will produce the outputs required.

It is very important for the project plan to be comprehensive and complete but sufficiently concise in order to be understandable by those using it. It should contain notes at crucial points to explain rationale and decisions. A well-prepared project plan provides a framework for risk assessments to be carried out. It may include mitigation tasks, although it plans for success and not failure. Finally, the title, issue, issue date, owners name and status date are trivial information that ensure that the correct document is discussed and investigated.

Activities (tasks) should be broken down to a suitable level of detail. Further detail can be added, if necessary, as the project progresses. The following types of activities should be included:

- Initiation activities
- Management activities, including milestones for management control (stage-gates)
- Quality activities
- Design activities
- Manufacture and assembly of prototype, evaluation and validation models
- Evaluation activities
- Validation activities
- Integrated logistics support activities
- Milestones for contract deliverables
- Milestones for contract payments (receipts from prime contractor and payments to subcontractors)
- Production activities (may be a summary task of a separate plan)
- Product design support activities (only including engineering hours to support design problems)

The typical task fields to be entered are: task ID, name, WBS, down stroke code, work (sum of work of the assigned resources), cost of materials, start date, finish date, and duration.

Labour resources and material resources should be assigned to "lowest level" (non-summary) tasks using generic skill codes. Typical resource fields include: name, group, maximum units available (labour only), type (labour or material), cost centre, cost centre manager, cost per use rate (materials only), cost accrual type (materials only), and base calendar.

A8.5.7 Concept Report

The Concept Report objective and contents have already been described in a previous section.

A8.5.8 Risk Management Plan and Risk Assessment

Risk Management aims to identify the risks which might jeopardise the achievement of the project aims so that timely action can be taken to avoid them or, if that is not possible, to mitigate their consequences. This is achieved by:

- identifying the risks, and;
- assessing their likelihood of occurrence and potential impact on the achievement of project aims.

This information forms the input to risk analysis which helps to prioritise the risks in terms of the expected benefit which will result in addressing them. Responding to risk involves the following activities:

- where risks can be avoided, take timely action to do so;
- where risks cannot be avoided, decide how to respond if they materialise;
- prepare contingency plans to implement these responses at the appropriate times and decide what events or conditions should trigger each plan;
- monitor the triggers and initiate contingency plans as required.

Regular independent and formal reviews of the project activities ensure that management is given early visibility of potential problems that may affect the project in terms of timescale, cost, and performance. The reviews also make the project team aware of the responses which are available to combat potential problems and the points at which decisions have to be made to trigger contingency plans or fall back options. The Project Manager is responsible for all aspects of Risk Management.

Risks are managed using the 4 steps described below, which will be repeated throughout the project.

Step 1: Risk Identification
Risks can be anything which could adversely affect the project aims, such as timescale, costs, or performance. Risk probabilities of occurrence and impacts can be classified as High, Medium, Low or Nil.

Step 2: Risk Analysis
Risk analysed to assess levels of Schedule, Cost and Performance Risk. This is documented in a Risk Register.
Uncertainties in schedule, cost, and performance that are identified may be analysed both qualitatively and quantitatively as appropriate.

Step 3: Risk Reduction (Planning)
This specifies, for the most important risks, what risk reduction actions are to be taken to reduce their likelihood and potential impacts, and who will be responsible for implementing them.

Step 4: Risk Handling (Management)

In this step Risks are reviewed for changes in probabilities and impacts, and for any new risks that may have arisen as a result of changed circumstances.

All identified risks are recorded on the Risk Register. Each record in the Risk Register includes the following data:

- the Phase or stage to which the risk applies; (ie. Development, Production, Support)
- the Risk Owner - i.e. the individual or department responsible for the risk;
- the probability of this risk occurring (High, Medium, Low, Nil), when and how;
- the impact (High, Medium, Low, Nil) on the activities at risk: Cost, Performance and Time;
- Risk Reduction Actions and Contingency Plans.

A8.5.9 Obsolescence Management Plan

The objective of this plan is to define strategies for identification of the effects of obsolescence through all stages of the product life cycle.

The project team should analyse the proposed project implementations, technologies and support strategies taking into account their potential obsolescence. There are three main risks that should be considered over the life of the product:

I. Impact of part being unavailable;

II. Likely cost of replacement;

III. Probability of obsolescence occurring.

Details of the analysis, decisions and resultant obsolescence plans should be recorded for reference at later reviews. The level of detail in the plan should increase as the project proceeds.

It may be necessary to apply different options to individual parts of a project and the choices made should be regularly reviewed as the project progresses. The main options for obsolescence to be considered are as follows:

- Do nothing until an obsolescence problem occurs. If chosen then resource for quick action must be available and identified in the plan.

- Define all interfaces between modules so that the consequences of obsolescence in any one module are bounded.
- Monitor the parts, materials and processes used in the product for approaching obsolescence. If this option is chosen then some of the monitoring process may be passed on to the suppliers. Possible actions resulting from this option is chosen then careful phasing in of the upgrades is required to prevent stock write-offs. This option can often result in lower manufacturing costs.
- Lifetime buy of important items.
- Design the product with alternative part options.

An estimate of costs involved for implementing the Obsolescence Management Plan should be made and sufficient funding budgeted for.

The obsolescence strategy should be reviewed during the design process and at regular intervals during production.

A8.5.10 Surveillance and Quality Plan

The purpose of the Surveillance and Quality Plans are to identify the QA surveillance activities against an order/contract as well as to record the details and results of any QA activities.

A Quality Control Surveillance Plan will be raised against appropriate contracts. The following activities are conducted as a Routine Surveillance:

a) Order/contract instructions reviewed
b) Internal audits and independent 3rd party assessments conducted against compliance to Quality System
c) Key suppliers/sub-contractors monitored by the company's Supplier Team
d) Pre despatch QA check on deliverables e.g. visual inspection prior to packaging, and inspection of the build records

Planned Surveillance is carried out in addition to Routine Surveillance and is normally applicable to new release products, non-standard products and for those orders with specific Quality requirements.

Quality plans are produced when required by a contract or when deemed beneficial by either the Programme Manager and or the Quality Engineer. The objective of the Quality Plan is to define, in addition to the company's Quality Manuals, procedures, personnel, and quality arrangements specific to the particular contract. The format of the Quality Plan shall be in accordance with Customer/Programme Manager requirements using Def Stan 05-97 and ISO10005 for guidance. Where possible, the Quality Plans should be approved by the Programme Manager.

A8.6 Development Phase

The Development phase comprises of the following steps:

Technical review - research and review of internal (future planned and existing)/external (new and existing) technical solutions that may meet requirement specification. A list of possible technical solution is prepared. Assess and select the technical solution for which we can meet the requirement specification. Also, identify whether or not we have the capacity to introduce the technical solution with the available resources (man, material, machine, special processes).

Initial system design - proposed costed overall system design(s) or agreed technical solution. Then the initial system design can be agreed and any outstanding issues can be identified.

Detailed design - proposed costed detailed design(s) based on block diagram, and interfaces. The outcome of this process step is a detailed design documentation.

Produce and Review Evaluation Models - produce costed batch of units, assess ease of assembly and assess functionality. This results to a number of working units/models.

Produce and Review Validation Models - Evaluate and characterise functionality against requirements. Specification acceptance by operations of the certified documentation package.

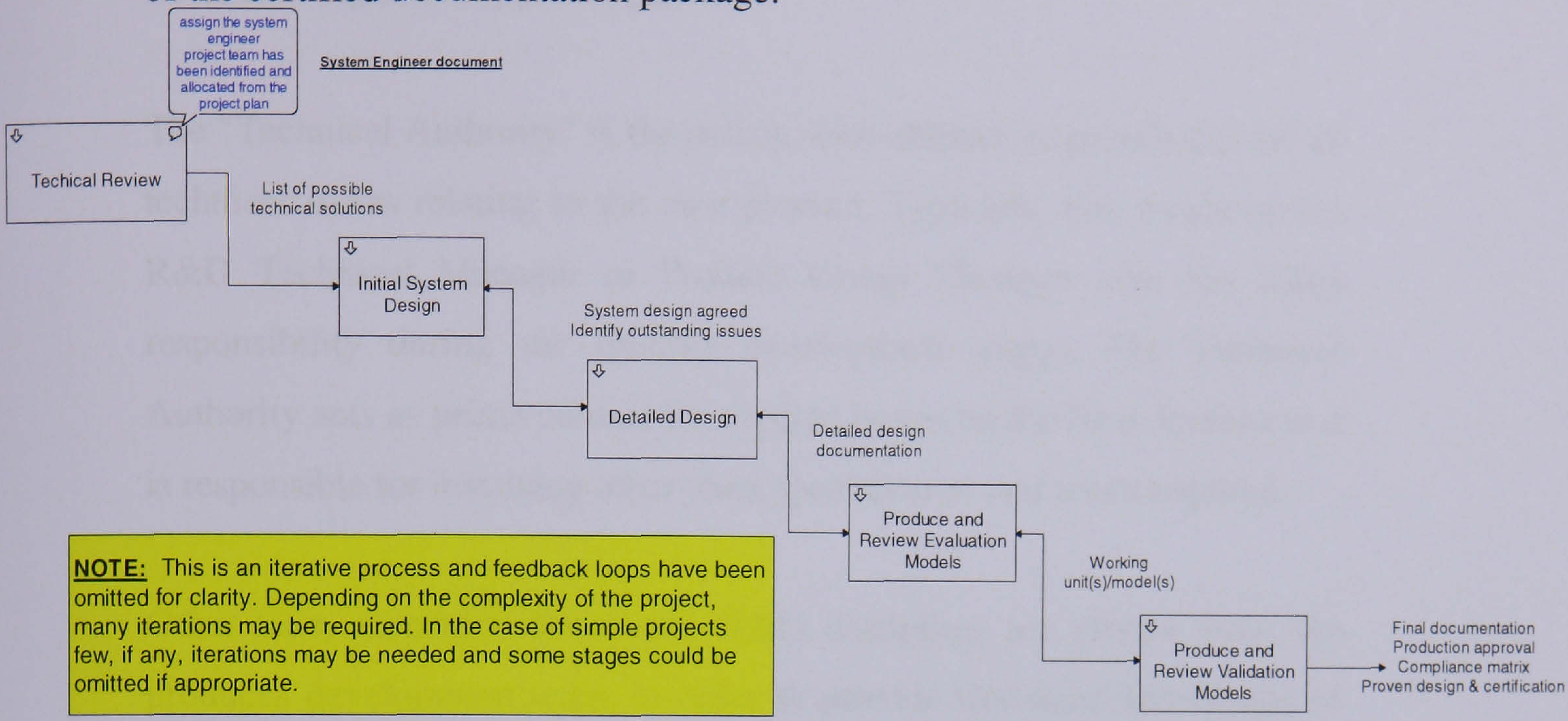


Figure A8.4. Development Phase (expanded from figure A8.1)

A8.7 Production Phase

This phase begins with the preparation of the facilities for the selected product and process technologies.

During the "Preparation" stages of the Production Phase of a NPI development, the Programme Manager in conjunction with the Project Manager will assign a Technical Support Team. This team will typically include the following:

Technical Authority (leader)

Scientist/biotechnologist (as appropriate)

Electronics engineer

Software engineer

Mechanical engineer

Integrated logistics support engineer

The "Technical Authority" is the person with ultimate responsibility for all technical issues relating to the new product. Typically, this would be the R&D Technical Manager or Product Group Manager who has taken responsibility during the product development stages. The Technical Authority acts as prime contact for support issues on the New Product and is responsible for involving other team specialists as and when required.

Other team members, from each R&D discipline, are chosen from the product's development team, in order to provide first-hand knowledge of any technical issues. The role of the team is to provide timely support and assistance to production throughout the life of the new product.

After the preparation of the production facilities and personnel, all is ready for the production of the 1st batch. When this is complete the units are reviewed as to their quality and function, the necessary adjustments can then be implemented in order for production to continue manufacturing the newly introduced product. The end of this activity is the phasing out of the product as soon as the market requirement is fulfilled.

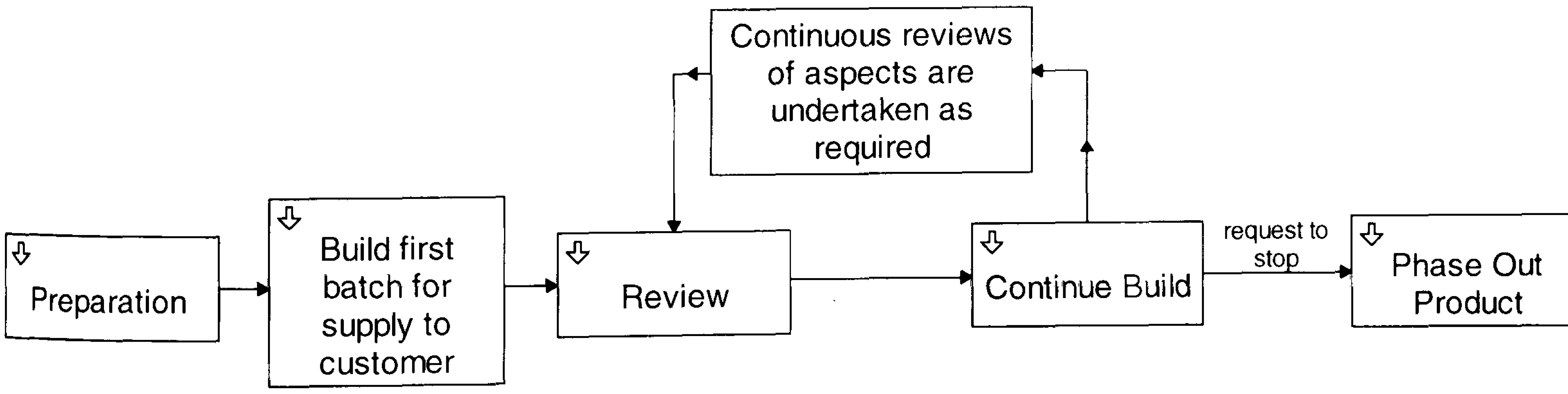


Figure A8.5. *Production Phase (expanded from figure A8.1)*

A8.8 Support Phase

This phase begins with the definition of the Support Policy. After the policy has been decided then the preparation of the support capability process begins. Its implementation follows and the process ends with the decision to end the support.

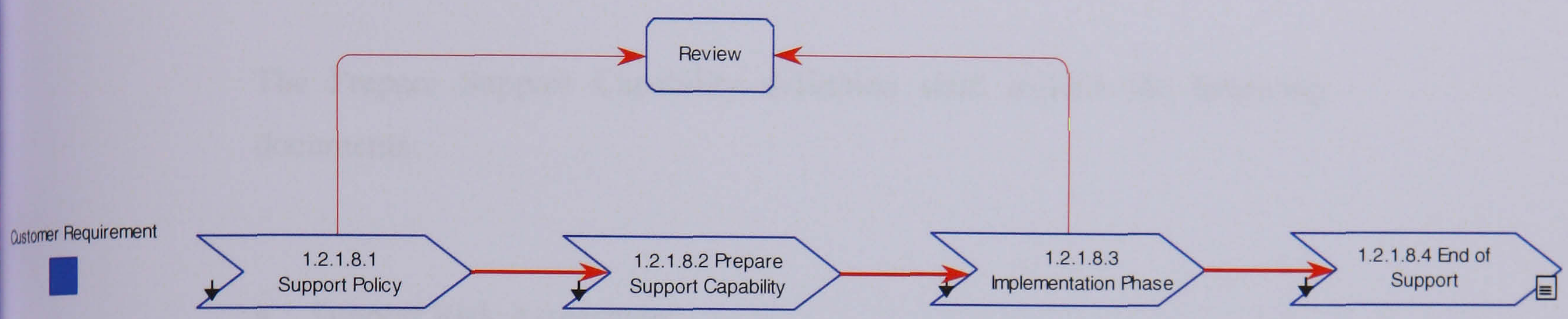


Figure A8.6. *Support Phase (expanded from figure A8.1)*

A8.8 Support Policy

The Support Policy definition shall include the following documents:

- Aspects of the Draft Integrated Support Plan (ISP)
- Logistic Support Analysis Plan
- Package, Handling, Storage and Transportation Plan (PHS & T)
- Supply Support Plan
- Training Support Plan
- Maintenance Plan
- Support Equipment Statement
- Technical Publications Plan
- Logistics Demonstration Plan

- Facilities Plan
- Post Production Support Plan
- Supportability, Test, Evaluation and Verification Plan
- Product Safety Case
- Human Factors Engineering (HFE) Management Plan

Prepare Support Capability

The Prepare Support Capability definition shall include the following documents:

- Support Risk Assessment
- Technical Support Assignment
- Obsolescence Support Management Plan
- KPI Requirement Plan
- Support Accounting Control Plan
- SOP Forecast Demand

Implementation Phase

For the Implementation Phase aspects of the following should be reviewed:

- Repair and Return Time
- Repair and Return Time - Actual vs Requirement
- Demand Forecasting
- Resources
- Skills/Training

- Skills Retention
- Test Equipment/Maintenance/Test Methods
- Data Storage and Retrieval
- Customer Feedback
- Design Feedback
- Obsolescence
- Cost
- TDPs/Configuration Control
- Documentation Update
- Environmental Legislation
- Disposal
- Risk
- Life Cycle Cost
- Health and Safety
- Support External - CLS
- BER Policy

End of Support

At this stage the impact of various aspects of the phasing out of the product will be reviewed and the following should be checked:

- Tooling/Test Equipment
- Core/Key Skills
- Disposal/Sale of Assets
- Documentation/Records (Storage & Retrieval)
- Accounting/Costs
- Supplier Management

- Health & Safety and Environmental Plan/Report
- Inventory Management
- Product Support/Timescales
- Request to Stop document
- Review Storage Space
- Disposal Obligation

General Note

At the end of each phase of the NPI process there is a "request to proceed" activity box. This is a document that identifies all the necessary outputs from every phase and if they are provided to the next stage. Then the project team decides whether the information is sufficient to continue to the next phase. Required actions, actionees, and completion dates are agreed at that point.

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