CRANFIELD UNIVERSITY

SCHOOL OF MANAGEMENT

M.Phil. Thesis

Academic Year 2005-2006

Z. Anagnostopoulos

PRODUCT SUPPORT AND THE NEW PRODUCT DEVELOPMENT PROCESS

Supervisors: M. Szwejczewski
K. Goffin

Abstract

Product support is a key aspect in the industrial marketing of not only high-technology products but also heavy goods and software applications, since it strongly influences customer satisfaction and can also be an important source of revenue. Typical elements of product support include installation, user training, equipment maintenance and, if necessary, repair – all of these are normally provided by manufacturers' support organisations. Despite its importance to several industries, support has not been extensively researched. This study describes the involvement of the support organisation in the new product development process.

Several authors have identified that product support is dependent on product design. Consequently, the same authors emphasise that support should be thoroughly evaluated during product design. This study identifies the elements of product support that may be evaluated and shows in detail how four companies in different industrial sectors evaluate support when developing new products. To further investigate the topic, two similar products per company were selected: one easy and one difficult to support.

The study investigated the differences in the development between the two products in terms of product support input in the new product development process. The results show that all companies had product support participating in their new product development processes, however product support was more involved in the easy than in the difficult to support products.

Compared to other research works and research publications, this research project took a step deeper inside the NPD teams in order to investigate the involvement of product support, the actions and targets set and the influence of product support. Consequently, the study provides a foundation from which there is real scope for further management research into what is becoming recognised as a vital element of industrial marketing.

Acknowledgements

This MPhil thesis would have been an impossible task without the direct and moral support of many people, all of whom I want to sincerely thank here.

Firstly, my thanks to Keith Goffin and Marek Szwejczewski for being excellent supervisors who, through suggestions, ideas, constructive criticism, patience and encouragement taught me how to conduct research into management. They managed to bring me the long way from my initial ideas of how a piece of research should be done to the real task, through their ability to work together as a team and give me complementary advice on different aspects of the research process.

It was stimulating to work at Cranfield School of Management, and many of the staff stood by me in the process of completing this thesis. Several lecturers gave advice at various stages of the project including the research reviews; my thanks to Simon Knox, Colin Pilbeam, Goke Adegoke, Dawn Gallyot, Wendy Habgood and particularly Graham Clark.

The topic of product support chosen for the research arose from an ESRC Collaborative Research Studentship (Award number: S42200034002) with a well-known automotive company. I would like to thank Peter Read, Robin England, Hans Gilham, Holger Cremer and Malcolm Reid for all their advice, suggestions and assistance in conducting the pilot case and in understanding the product support issues from an automotive perspective.

During the course of the project, over five hundred books and articles were consulted, thanks to the assistance of the staff of the King Norton Library. I am very grateful to Anita Beal who helped in quickly tracing references, obtaining inter-library loans for me and assisting when I was back from my military service.

Conducting the cases was not an easy task, especially as it was necessary to arrange several interviews in the same visit. I would really like to thank all managers who participated in the interviews, tried to extract documents relevant to the topic of product support but most of all I would like to thank the managers who arranged all visits in each case, something that proved to be the most important aspect of my data collection.

Moral support was really essential as there were times, especially during my army break, when the whole project looked impossible to complete. People really close to me encouraged me to continue investing time and effort in it, as I was a long way in it (or, as Greeks say, I had eaten the donkey and I had left the tail out). My gratitude to my mother, Maria Anagnostopoulou. Friends who offered regular motivation include Sofia Papadimitriou, Dimitrios Krikelis, Vasilis Krikelis, James Collins and Ruth Barratt.

It is true that without the understanding, patience and inspiration of my partner, Marianthi Papadimitriou I would never have found the energy to complete this research. She is the one who was steadily pushing me in writing my ideas down and she has never stopped believing in me. I would like to dedicate this thesis to Marianthi, as without her this thesis would have never been successful.

Athens, Greece, April 2006

Contents

Figures

Tables

CHAPTER 1. INTRODUCTION

1.1. The Research Topic – Product Support

Product support is the various forms of assistance that companies offer customers to help them gain maximum value from manufactured products (Goffin, 2000). Although it is less well-known, manufacturers have recognised the importance of helping their customers to use the products effectively. The aim of manufacturers is to keep customers satisfied with the product and, having succeeded, maybe to generate future sales from customer loyalty. Customer service and, more importantly, product support is a means to achieve that, as it will be illustrated in the rest of the paper.

This thesis presents the aims of the research and its findings. It covers the literature identified in the areas of customer service, customer support and the new product development. The literature related to how product support requirements are taken into account during the NPD process is given particular attention, as this research focuses particularly in those issues. The gaps related to the incorporation of product support in the NPD process are identified leading, finally, to the research questions. The methodology used to investigate the research questions is presented, together the findings of each of the cases. Finally a cross-case analysis is presented, together with the limitations of this study and propositions for further research.

1.2. Rationale for the Research

It was in 1974 that the term customer support (referred to previously as after-sales support) first appeared in the literature in an article of Perreault and Russ (1974). Since then, several studies have investigated the importance of customer support in a range of industries: the scientific instrument and supplies industry (Gilmour *et al.*, 1977), power tool manufacturer (Emerson and Grimm, 1996; 1998; 1999), industrial and raw materials (Kyj and Kyj, 1989), computer industry (Loomba, 1996; 1998). Other studies, focused on: a) the elements of customer support which were important for a range of industries (Goffin, 1990; 1994; Goffin, Szwejczewski and New, 1997; Goffin, 1998; 1999), and b) service parts and customer support management (Hull and Cox, 1994).

There are several reasons for conducting a research in this area:

1. A large number of authors have suggested that manufacturers' provision of repair and maintenance (which are elements of customer support) for products is an important aspect of customer care (Davidow, 1986; Little, Mosquera and Wild, 1988; Bowen, Siehl and Schneider, 1989; Kyj and Kyj, 1989; Miskie, 1989; Knecht, Leszinski and Weber, 1993; Hull and Cox, 1994; Burger and Cann, 1995; Haggblom, Calantone and Benedetto, 1995; Cohen and Whang, 1997; Lele, 1997; Fortuin and Martin, 1999; Phelan, Griffiths and Fisher, 2000). If manufacturers provide good customer support quality, they might achieve customer loyalty, with benefits after the actual sale of the product, in terms of revenues from the service organisation or the sales of spare parts (Teresko, 1994; Athaide, Meyers and Wilemon, 1996). Therefore studies in

customer support and its management are going to be of great help for manufacturers in many industries

2. Some authors express the need to take into account customer support when designing new products (Lele and Karmarkar, 1983; Lele, 1986; Hegde and Kubat, 1989; Goffin, 1990; Teresko, 1994; Galloway, 1996), as customer support is an important factor behind the success of new products (Cooper and Kleinschmidt, 1993; Swink, Sandvig and Mabert, 1996; Poolton and Barclay, 1998; Benedetto, 1999).
3. Although there is ample anecdotal evidence that customer support is an essential aspect in the marketing and the design of many products, not enough research has focused on this area (Hull and Cox, 1994). Only some exploratory studies have been conducted recently with the development and design of new products in mind (Goffin, 1998; 1999; 2000; Goffin and New, 2001).
4. As many authors state, the final cost of the product, as well as the cost over its lifetime, is determined by the decisions made at the early stages of the product development (Bacon *et al.*, 1994; Srinivasan, Lovejoy and Beach, 1997; Bhattacharya, Krishnan and Mahajan, 1998; Gu and Sosale, 1999). Several authors suggest that customer support requirements should be considered at the design stage (Armistead and Clark, 1992; Cespedes, 1995; Goffin, 1998). However, Goffin (1998) showed that many companies do not consider customer support requirements until they are well into the new product development process, where most of the decisions about the final product have already been made.
5. Customer support has become a major issue for the sponsoring company, which sponsors this MPhil project. Managers in the NPD and the after-sales support departments have expressed the need to produce new cars, which will be easier to repair and use, as this will create revenues for the company and, at the same time, make the use of their products less troublesome for their customers.

1.3. Aims of the Research

This research tries to address the problem of how product support requirements are evaluated at the design stage of new products. In particular, it has the following two aims:

1. To determine how different companies evaluate product support requirements
2. To identify the timing of involvement of product support in the new product development process.

The results of the analysis are presented in Table 47, page 132.

1.4. Expected Contribution

This thesis is expected to contribute to both a) the knowledge/theory in the area of product support and b) the practice.

a. The in-depth case studies, with numerous interviews with managers (5-10 managers per company instead of 1-2 in previous works) and documentation, will give insight to the involvement of product support in the new product

development processes employed by leading companies in various sectors. No case study conducted to date has been so detailed. All actions taken during the development of two products per company will be investigated in detail in an effort a) to provide as much detailed description of the actions and processes as possible and b) to provide reasonable explanations for the choices made by the managers. Another important contribution of this thesis to the knowledge in this area is that it includes an investigation of product support involvement in the product development process of an infrastructure systems software company, an unexplored area until today in terms of product support.

b. The practices from leading companies in four industrial sectors can show the latest developments regarding product support in their sectors and provide a path for other companies to follow. Additionally, managers of product development or product support might benefit by viewing the way companies in other industrial sectors have approached product support (i.e. managers in automotive companies might benefit from the approach followed by their counterparts in heavy equipment companies).

1.5. Structure of the Thesis

The next chapter of this thesis (chapter 2) is the literature review covering the knowledge in the areas of customer service, product support and new product development until today. It will be followed by chapter 3, in which the methodology employed in this research study will be described in detail. The pilot case study will be presented in chapter 4 and will be followed by the chapters 5-7 with the case studies of electronics, software and heavy equipment companies respectively. In chapter 8 a cross-case analysis of the findings will be made, followed by the discussion (chapter 9) and the conclusion (chapter 10) of this thesis.

1.6. Summary

There is ample anecdotal evidence that customer support is an essential aspect in the marketing and the design of many products but not enough research has focused on this area. This thesis will try to address this problem by focusing on how product support requirements are evaluated at the design stage of new products in four case companies that belong to four different industrial sectors. In the next chapter, a description of the broader context of the research will be made on the chapter of literature review.

CHAPTER 2. LITERATURE REVIEW

2.1. Introduction

The review of the literature was conducted to identify possible gaps relevant to the field of study. It covers:

- Customer service: Explaining the broad meaning of this term in business transactions
- Product support: Showing how companies offer support to enable their customers get maximum value from their products
- New product development: Demonstrating the decisions that are taken when developing new products, both at the firm and the single project levels
- Overall summary: Linking customer support with new product development, identifying the gaps in the literature and suggesting the future direction of the research

2.2. Customer Service – Explanation of the Term

According to Kyj and Kyj (1989), customer service aims to facilitate the sale and use of a firm's products or services and it is offered as a supplement of the core product offering of the firm. Similarly, Wagner and LaGarce (1981) note that customer service expands the product offering and thereby offers the possibility of giving the firm's products market acceptance, growth, and the possibility of market dominance. The term customer service also "emphasizes the general quality of interactions between a seller and a customer (from the latter's point of view)" (Parasuraman, 1998).

Tucker (1983) identified two classifications of customer service: the marketing approach and the physical distribution orientation. The marketing orientation includes all the activities existing to sell the product and gain repeat sales. Tucker's explanation of the physical distribution approach to customer service states that it is the interface between the company's order, delivery and information system and the customer. She also includes, under the umbrella of the physical distribution approach, the product service orientation, as providers view customer service as necessary to maintain customer satisfaction, loyalty and control of the product's end-use value. She argues that achieving outstanding customer service is a complex target, as it requires coordination of the activities of both logistics and marketing functions.

Customer service is a series of activities prior, during and after the transaction (Kyj and Kyj, 1989). Gilmour *et al.* (1977), in an investigation of the importance of several elements of customer service in the scientific instruments and supplies industry, concluded that customer service consists of many elements, including the following:

- Availability of the item
- After-sales service and back-up
- Efficient telephone handling of orders and queries
- Ordering convenience
- Competent technical representatives
- Delivery time
- Reliability of delivery

- Demonstrations of equipment
- Availability of published material

Kyj and Kyj (1989) conducted similar research to that of Gilmour *et al.*, in the industrial market for raw and manufactured materials (including silicates, cement and concrete, heating oil, industrial gases, rubber and food ingredients). They argue that the elements included in the list might have different importance for different customers. Emerson and Grimm (1996; 1998) tested a model of integration between the logistics and marketing orientations of customer service in the power tool manufacturing industry. Their conclusion is that, overall, there are three logistics and four marketing dimensions of customer service, most of which are covered in the above list. In the following section, the need for research in this area will be demonstrated, followed by an explanation of the terms customer support and product support.

2.3. The Need for Research

Researchers in both the operations management and marketing areas have conducted numerous studies of customer service, covering its management, its quality and the ways it can become a strategic weapon. Customer support is a specific type of customer service, offered by manufacturers of industrial equipment (e.g. heavy equipment, computing, medical electronics, telecommunications etc.) and sometimes consumer equipment (computing, automotive, domestic appliances etc.). Although it is recognised as an important priority for study, it has not been highly researched (Loomba, 1996; Goffin, 2000). This area of customer service will be explored in more detail in the next paragraphs, with particular emphasis on its elements and its importance for the manufacturers in today's marketplace.

2.4. Product Support

This section will discuss the variety of definitions regarding customer support, after-sales support and product support in order to make the terms clearer. For Loomba (1998), "[*customer support*] *issues entail all activities undertaken by service support providers (manufacturers, retailers and/or independent servicers) to ensure that a product is available for trouble-free use to consumers over its useful life span*". This definition is not explicit for the satisfaction of the customer from the use of the product. Lele and Karmarkar (1983) take into account customer satisfaction and define after-sales support as: "[after-sales support] *encompasses everything that can help maximise the customer's after-sales satisfaction*". Nonetheless, satisfaction might derive from various sources other than after-sales support, such as product performance, other people's admiration for the product design etc. A definition that encompasses the time element in customer satisfaction is provided by Hegde and Kubat (1989), who define customer support as "*a set of goods and services associated with a durable product to ensure the continued 'satisfactory' use of the product after the sale*". A close definition to this one is provided by Goffin (2000). Goffin identifies customer support as "*the various forms of assistance that companies offer customers to help them gain maximum value from manufactured products*". However, customer satisfaction is not included in Goffin's definition. A common theme to all those definitions is the treatment of customer support as an after-sales experience for the customer. At this point, one must explain that product support is a subcategory of customer support. For the purposes of this research, product support is defined as "*the*

various forms of assistance, undertaken by service support providers (manufacturers, retailers and/or independent providers) that companies offer customers to help them gain maximum uninterrupted usage and value from manufactured products, from the time of the sale to the time of disposal".

Product support takes several forms depending on the industrial setting and on the way particular companies view their customers' requirements. In the next section, the elements that constitute product support will be described.

2.5. Elements of Product Support

According to Lele (1986), customer support activities are the provision of parts, service, and warranty plus operator training, maintenance training, parts delivery, reliability engineering, serviceability engineering, and even product design. For Goffin (2000), customer support includes the installation of the equipment, training on a product, maintenance and repair services (generally termed service), documentation, availability of spare parts, upgrades (enhanced functionality), customer consulting, and warranty schemes.

As a concept, customer support addresses the user needs after the actual sale of the product, including, not only the service of the product when it fails, but also all the needs of the customer during the lifetime of the product, like training or telephone help line (Figure 1).

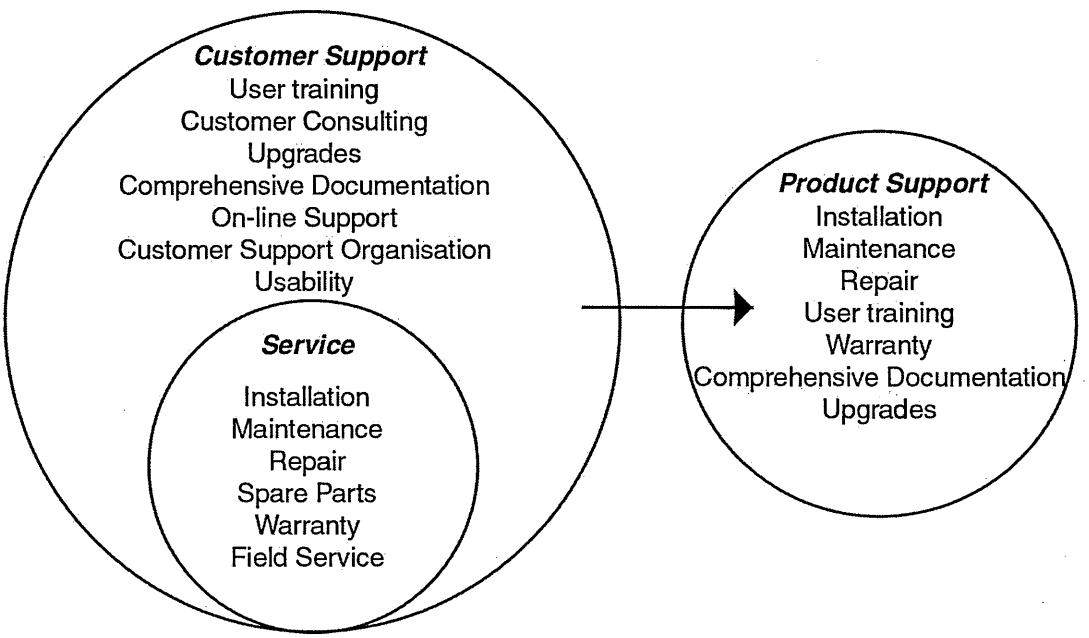

Figure 1: Customer support is a broader concept than service itself (modified from (Goffin, 2000))

As shown in Figure 1 customer support consists of 13 elements. Product support consists of all the elements of customer support that are directly affected by the product design. These are the following eight (8):

1. Installation
2. Repair
3. Maintenance
4. Warranty/ Cost of Ownership

5. Comprehensive Documentation
6. Upgrades
7. User Training

The remaining 5 elements of customer support are indirectly affected by the product design and depend on the manufacturer's organisation. The organisation-related elements deal with the response of the manufacturer to the problems customers face while purchasing and operating the product. For example, a professional and friendly customer support organisation can achieve customer satisfaction independently of the product design. These elements are:

1. Customer Consulting
2. On-line Support
3. Spare Parts
4. Usability
5. Customer Support Organisation
6. Field Service

For the purposes of this research, the following activities of customer support will be regarded as core and will be further explained below:

2.5.1. Installation

The installation of the equipment is an element of product support identified in many industrial products. Examples where installation is important include the manufacturing equipment, like lathes, robots etc. and the computer systems and mainframes. According to Goffin (1999), there are two types of installation. The first type is the installation conducted by personnel from the manufacturing company. It occurs in the case of complex products (e.g. computer systems) or products where safety is important (e.g. medical or food processing equipment) (Cespedes, 1995). The second type of installation is that undertaken by the customer. In this case, manufacturers try to create products that are easy to install, even for non-technical minded people. An example is the portable computer, which is almost always sold ready to use. Installing a new device (e.g. modem, network card, CD-ROM etc.), in notebooks, can be really easy, as new devices for those computers do not require an expertise in computer architecture. This change on the design for easy installation is often considered as important, from both the customers' and the manufacturers' points of view.

2.5.2. User Training

Most complex products require some training of the users by the manufacturers (Goffin, 1999). For example, manufacturing personnel need to be trained in order to be able use the latest computer-aided manufacturing technology, as many of them have limited previous experience (Athaide, Meyers and Wilemon, 1996). The lack of skills training from the manufacturer often leads to the rejection of new technology as no one knows how to best use it for the company's benefits (ibid). Although the user training is one of the attributes that can generate sales for a product that requires technical skills to use (Mathe, 1986), training costs can still be very high, as manufacturers must devote resources to educate the customers. Goffin (1999) notes

that simple products do not require user training and most of the information about how to use the product are included in the documentation provided with the product.

2.5.3. Documentation

Most products are accompanied with some form of documentation, which might play an important role in the equipment operation and maintenance (Miskie, 1989). Miskie argues that good documentation can lead to lower support costs and increased productivity for the customer. However, as he notes in his article, the documentation for many products is poorly written and hard to understand. Nowadays, new technologies can have a major impact in the documentation of many products. For example, user-friendly Internet-based documentation is an increasingly used resource for troubleshooting information for both software and computer products (Phelan, Griffiths and Fisher, 2000).

2.5.4. Repair

For many years, this has been the key element of product support in many industries and some people equal customer support solely with the provision of this element (Cohen and Whang, 1997). In many industries the "down-time costs run typically at anywhere from 100 to 10,000 times the prices of spare parts or service" (Knecht, Leszinski and Weber, 1993), showing the need for fast and efficient repair. There are many ways to reduce the down-time costs. The first way is to produce equipment that is very reliable (or never fails) (Davidow, 1986). This increased reliability can be based on the production of the product (tolerances, materials etc.) or by double and triple redundancy of the critical parts of the equipment, in such a way that when one part fails, the performance of the equipment will still be the same. An example of the use of these redundancies is the aircraft industry (Knezevic, 1999). Large passenger aircrafts usually operate with four engines. Even in the case of two engine failures, the aircraft can still reach its destination using the other two engines. Another way, proposed by Lele and Karmarkar (1983), is the rapid response to expedite repairs. Some companies focused on efficient logistics management of spare parts to gain advantage over their competitors (Hull and Cox, 1994). The repair of the equipment can also be facilitated by the use of good diagnostics, an efficient way to inform the users for problems and to identify the causes of those problems (Hegde and Kubat, 1989). The attractiveness of the use of diagnostics depends upon the costs customers face when the equipment is down. These are separated to two types: fixed costs, which occur regardless on the time the equipment is down (like spare parts and labour involved in fixing a failure), and variable costs, which depend on the down-time of the equipment (like lost opportunity costs or production costs).

2.5.5. Maintenance

Maintenance, which is also referred to as preventive maintenance, is the process of cleaning, refurbishing or replacing parts of equipment, which wear and are therefore liable to fail (Goffin, 1999). Manufacturers can benefit from the maintenance provision to their customers by: a) the revenue from the spare parts sold to the customers, b) premium charges for some customers who are willing to pay more in order to have their equipment up and running all-round the clock. In manufacturing equipment, the mechanical parts normally require regular maintenance. However, in the computer industry, where the number of mechanical parts is reduced, remote

support technology enables computers to be up-dated, diagnosed and repaired by creating direct links with the manufacturers' support centres over the World Wide Web (Connor, 1999). Heavy equipment manufacturers also try to use similar approaches, by remotely monitor the equipment and provide maintenance before the fault occurs (Fites, 1996). They also made a step further, by re-designing of the product in order to ease the ability to reach a component that needs to be changed (Knezevic, 1999; Mercer, 1999).

2.5.6. Online Support

In many industries, the support provided by product experts over the telephone or over the World Wide Web is becoming a major element of product support (Anagnostopoulos, Goffin and Szwejczewski, 2001). This support is not focused only on consulting, but also on troubleshooting and on updated information to avoid future problems. For example, the Dell company have found that if they are provided with step-by-step information, clients can solve almost 30% of typical problems without the intervention of the product support personnel (ibid.). Online support is extensively utilised for the software and computer products (Armistead and Clark, 1992; Connor, 1999), and many companies use this element as a competitive weapon in the marketplace (Connor, 1999), trying to create more value for the customers and achieve increased customer satisfaction levels (El Sawy and Bowles, 1997; Marsan, 2000).

2.5.7. Warranty

This term refers to the financial protection of the customers provided against any deficiencies or malfunctioning of the purchased equipment for a period of time. During that period, customers can have free service and/or may return the faulty equipment back to the manufacturer for a new one. Many types of products are accompanied with warranty and in some cases warranty is used as a weapon to gain competitive advantage. Automobiles are such a case. Warranty reduces the financial risk of buying and using the product, and therefore it is an important element of customer support (Loomba, 1996; Lele, 1997). The financial burden a customer faces for using a product over its lifetime might be greater than the initial purchase price (Davidow, 1986; Knecht, Leszinski and Weber, 1993; Ealey and Troyano-Bermudez, 2000). Especially when considering complex products, the support cost is very high for the customers. This cost is referred to as cost-of-ownership and its decrease is highly demanded nowadays by customers (Loomba, 1996). Manufacturers have realised that and, in order to reduce the risk of expensive repairs, they offer to their customers the possibility to purchase warranty extension.

2.5.8. Upgrades

Another important aspect of product support is to offer customers the chance to enhance the performance of existing products by adding or replacing modules with ones that have better performance (Davidow, 1986; Cespedes, 1995; Athaide, Meyers and Wilemon, 1996). Upgrades are extensively used by computer manufacturers, as they increase the working lifetime of products and, in the same time, can be a significant source of revenue (Knecht, Leszinski and Weber, 1993). Original equipment manufacturers take advantage of this opportunity, as they have records of

where the equipment has been sold and can address the need of the particular customer for enhanced performance (ibid).

A summary of the elements of product support and the key points from the references found in the literature is presented in Table 1.

	Element	References	Key points from the references
1	Installation	(Goffin, 1999) (Cespedes, 1995)	Two types of installation: a) from personnel (complex products) and b) from the customers (software products or portable computers)
2	User training	(Goffin, 1999) (Athaide, Meyers and Wilemon, 1996) (Mathe, 1986)	Complex products require user training. Lack of skill training leads to rejection of the product. Manufacturers must devote resources to train customers
3	Documentation	(Miskie, 1989) (Phelan, Griffiths and Fisher, 2000)	Good documentation might lead to lower support costs and increased productivity for the customer. New technologies (e.g. Internet) could be used as resources for troubleshooting information
4	Maintenance and repair	(Connor, 1999) (Davidow, 1986) (Fites, 1996) (Goffin, 1999) (Hegde and Kubat, 1989) (Knecht, Leszinski and Weber, 1993) (Knezevic, 1999) (Lele and Karmarkar, 1983) (Mercer, 1999)	The down-time costs are very high. These can be reduced by: a) very reliable equipment, b) rapid response to expedite repairs, c) use of diagnostics Maintenance can be a source of revenues due to the spare parts sales and the premium charges. Remote monitoring of the equipment facilitates maintenance
5	Online support	(Anagnostopoulos, Goffin and Szwejczewski, 2001) (Armistead and Clark, 1992) (Connor, 1999) (El Sawy and Bowles, 1997) (Marsan, 2000)	Troubleshooting and consulting over the Web is becoming a major element of customer support (especially for software and computer products). Might lead to increased customer satisfaction
6	Warranty	(Lele, 1997) (Loomba, 1996) (Davidow, 1986) (Ealey and Troyano-Bermudez, 2000) (Knecht, Leszinski and Weber, 1993)	In many cases warranty is used as a weapon to competitive advantage. The financial burden of using a product might be greater than the initial purchase price. Customers demand reduction of the cost-of-ownership
7	Upgrades	(Athaide, Meyers and Wilemon, 1996) (Cespedes, 1995) (Davidow, 1986) (Knecht, Leszinski and Weber, 1993)	Upgrades are extensively used in computer products. They increase the products' working lifetime and can be a significant source of revenue for the manufacturers.

Table 1: Elements of product support and related literature

Some of the elements presented above are used competitively in the market, as manufacturers make considerable efforts to address their customers' needs to new products. In the next paragraphs, the reasons behind this concern of keeping customers satisfied will be shown, focusing exclusively in the importance of product support.

2.6. Importance of Product Support

There are several reasons to why providing good product support is important to manufacturers:

1. It can give manufacturers a competitive advantage (Lele, 1986; Hull and Cox, 1994)
2. It is a means to customer satisfaction (Loomba, 1998)
3. It is important for the success of new products (Cooper and Kleinschmidt, 1993)
4. It can be a source of revenue (Davidow, 1986; Knecht, Leszinski and Weber, 1993)

A description of the above factors will be presented in the following paragraphs.

1. Product support has been noted as providing a competitive edge in a range of industries, including heavy equipment, computers, telecommunications hardware, and industrial machinery (Lele, 1986; Hull and Cox, 1994). As product technologies are spreading fast, products are becoming similar and their performance less and less differentiated (Bouckaert, Deneffe and Vantrappen, 1997). In such competitive markets, manufacturing companies are striving for the competitive differentiation that will give them more profits. Loomba (1998) states differentiation can be achieved through good product support. Many firms use product support in order to get more sales (Mathe, 1986; Loomba, 1996) and product support has been related to higher market share (Benedetto, 1999). Loomba (1996) refers to the factors that could have caused this behaviour from the companies:
    - products are now more complex and more service-sensitive
    - there is a greater customer awareness of rights regarding warranty servicing
    - inflationary pressures are creating greater sensitivity to repair costs
    - there are instances of poor design as well as a decline in product consistency
    - inexperienced and unqualified personnel are after undertaking the maintenance and service of products
    - increased incidents of product misuse by the customer have occurred

2. Product support can lead to customer satisfaction through: a) lower cost of ownership, and b) customer loyalty.

   The literature suggests that product support allows customers to gain maximum value from their purchases (Athaide, Meyers and Wilemon, 1996; Goffin and New, 2001). This value derives from the use of the product at its best performance for a longer period of time throughout its life cycle or from

the lower cost of ownership that occurs to the users of the product. Davidow (1986) noted that sophisticated customers tended to evaluate both the price of the product and the savings due to good service before buying high-tech equipment.

Mathe (1986) argues that product support provides an excellent basis for creating a communication link between a firm and its customers, the so-called "partner relationship". The shapes this communication link could take are various: customer advice to define the technical performance and maintenance characteristics of new products; joint research for better operation of the equipment, taking into account particular customer constraints and objectives, and more (ibid.). The partner relationship might lead to customer loyalty with direct benefits for the manufacturers both before and after the actual product sale (Teresko, 1994; Cespedes, 1995; Athaide, Meyers and Wilemon, 1996) due to repeated and increased business (Lewis, 1995; Aschner, 1999). Lewis (1995) and Phelan *et al.* (2000) support the view that this loyalty is actually more cost-effective than trying to attract new customers. Still, manufacturers might attract new customers due to positive word-of-mouth communication (Lewis, 1995; Aschner, 1999).

3. Moving to the third reason, it has been found that product support plays a role in the success of new products (Cooper and Kleinschmidt, 1993; Benedetto, 1999). Cooper (1993) states, "*Where the firm offers superior technical support and customer service with its new product, success rates are markedly higher*". In a more recent article (1999), he emphasises that delivering a product with unique benefits and superior value for the users is a top success factor. As mentioned above, such superior value products can mainly be delivered when firms provide good product support.

4. From the literature it appears that product support has always been a significant source of revenue. For example, in the 1980s Mathe (1986) presented the results of a study, which showed that in the data processing, office automation and telecommunication industries income from hardware and software support has constantly grown since 1980. During the same year, it has been revealed that the service bill over a five-year useful life of a high-tech piece of equipment is typically greater than 50% of the price of the equipment (Davidow, 1986). Knecht, Leszinski and Weber (1993) add that after-sales support could generate at least three times the turnover of the original purchase, especially for industrial equipment. More recently, Ealey and Troyano-Bermudez (2000) noted that, in the automotive industry, 60 percent of light-vehicle revenues are found in service, parts, and ancillary products. Consequently, product support could be used as a major source of revenue for the industries (Knecht, Leszinski and Weber, 1993; Hull and Cox, 1994).

Several researchers contend that the design of new products could be improved from the feedback provided by the product support function (Lele, 1986; Mathe, 1986; Athaide, Meyers and Wilemon, 1996; Davenport and Klahr, 1998). For example, the design of the product has an immediate effects on the product's reliability and,

consequently, on the frequency of its maintenance and repair (Lele, 1986). There are several ways to design products for easier product support: a) the Design for Service (DFS), and b) the Design for Supportability (DFS-II).

a) The DFS methodology evaluates, at the design stage, how a product will be serviced (Parker, 1993). Goals are set for the service requirements before the start of the development in order to ensure high serviceability (Teresko, 1994). However, Davidow (1986) emphasises the need to evaluate not only service issues, but also all aspects of customer support at the design of new products.
b) Goffin (1998) proposed the Design for Supportability (DFS-II) methodology, which includes the evaluation of product support requirements at the design stage of a product, based on the involvement of engineers with experience of product support in the development of new products (Knecht, Leszinski and Weber, 1993; Hull and Cox, 1994). Recent research revealed that companies not only struggled with the service costs and the repair of their products due to the lack of such involvement (Anthoney and McKay, 1992), but considered product support requirements late in the NPD process (Goffin, 2000).

The literature recognises that product design has a big influence on product support. The two methodologies presented above are tools that can be employed during the development process for new products. It is therefore important to understand the new product development process through the vast amount of literature that has been published in the area.

2.7. New Product Development Process

New product development in this research refers to the transformation of a market opportunity into a product available for sale, placing the focus on the product development projects within a single firm. This is in contrast to much of the literature on technological innovation, which addresses innovation at the level of entire industry (e.g. Utterback, 1994). Product development is viewed as a sequence of fundamental decisions that are made intentionally and that can be supported by knowledge and tools (Clark and Fujimoto, 1991). We must note, however, that there is not a strict sequence of those decisions, rather the decisions are inter-related and inter-dependent. One could easily argue that the sequence of taking the decisions is itself a decision related to the product development and is derived from the product development organisation. Inputs to this product development decision-making process are the market opportunity, as perceived by those involved with the customers, and the assumptions concerning the product technology and the production or delivery system.

A review of the literature that is related to the decisions made during the product development process is provided by Krishnan and Ulrich (1998). According to their review the product development decisions can be split into two broad categories. The decisions made when setting up the product development process itself (as these tend to depend on other decisions made at the top management of an organisation) and the decisions made within the context of a single new product development project.

2.7.1. Decisions Made When Setting Up the NPD Process

The decisions related to the set-up of product development projects can be divided into the decisions relating to *product planning*, *product development organisation*, and *project management* that prepare the ground for the individual product development project.

2.7.1.1. Product Planning

The product planning includes the decisions about the product mix, prioritisation of the different projects, allocation of the resources and selection of the appropriate technology. The decisions to be made are: What portfolio opportunities will be pursued? What is the timing and sequence of the product development projects? What assets will be shared across products? Which technologies will be employed in the planned products?

Much of the marketing literature the last few years focuses on the product portfolio selection. This portfolio management is defined as the process of evaluation, selection and prioritisation of new products; the acceleration or abortion of existing products; and the allocation of resources to the development of active products, whether existing or new (Cooper, Edgett and Kleinschmidt, 1997a).

In their research of portfolio management practices in industry, Cooper *et al.* (1997a; 1997b) investigated 35 leading firms in various industries, ranging from chemicals to high-tech materials and consumer goods producers and created a framework that links the portfolio management process to the Stage-Gate model of product development. Ali, Kalwani and Kovenock (1993) presented a taxonomy of the problem of product/project selection taking into account the degree of innovativeness of the new product (truly innovative or product modification) and the market environment (monopolistic or competitive). Another problem in this category is the *product line design problem*, which deals with the selection of the number and identity of individual products. Several decision support models based on heuristic procedures have been developed from Kohli and Sukumar (1990) and Dobson and Kalish (1993).

When launching a new product, the firm decides the timing and sequence of product introduction. One of the trade-offs confronting the timing decision is one of cannibalisation of existing products (when products are introduced simultaneously, low-end products might cannibalise the sales of high-end products) over faster increase of profit (Krishnan and Ulrich, 1998).

Some of the decisions at the product planning level concern the allocation of the development resources. Substantial sharing of these resources across different products is also referred to as *platform product development*. Several researchers argue that the use of this sharing leads to better utilisation of resources, reduction in the required development hours, and better learning transfer across products (Nobeoka, 1995; Nobeoka and Cusumano, 1997). Although much of the literature in this area focuses on platform benefits, Adler *et al.* (1995) tried to highlight some of the pitfalls of some forms of resource sharing, as the congestion arising from high processing time variability and high capacity utilisation. Robertson and Ulrich (1998)

argue that the use of platforms might lead to similar products from the customers' point of view, thus losing the customer-perceived differentiation of the products.

Another decision during product planning is that of which technologies to incorporate in a forthcoming product. Iansiti (1995b) investigated the development of computer mainframes based on novel technical capabilities. The difficulty of such a development is increased due to the rapid evolution and the uncertainty of the technical components contained in a mainframe, which in turn increased the complexity of their interactions on the complete final product. Although these technologies are appealing to the firm, they are not fully proven and are very risky to adapt into new products.

2.7.1.2. Product Development Organisation

The product development organisation is the social environment in which the product development work is carried out (Ulrich and Eppinger, 2000). Decisions in this category include the following: Will a functional, project, or matrix organisation be used? How will the team be staffed? How will project performance be measured? What will be the physical arrangements and location of the team? What investments in infrastructure, tools and training will be made? What type of development process will be employed (e.g. waterfall or stage-gate)?

The individuals comprising the product development organisation can be classified in two different ways (Ulrich and Eppinger, 2000): according to their *function*, namely the area of responsibility involving specialised education or experience, and according to the *projects* they work on, which might be identifying customer needs or generating product concepts etc. Two classic organisational structures are based on the alignment of the organisational links according the above-described classifications, the *functional organisation* and the *project organisation*. Another organisational structure that arises as a hybrid of the functional and the project organisation, the *matrix organisation*, in which individuals are linked to others according to both the project they work on and their function (Ulrich and Eppinger, 2000).

Dougherty (1992) tried to investigate the barriers to successful product innovation using 80 individuals, from various departments, involved in 18 new product efforts from different companies. She emphasises that, for the innovation to be successful, collective action or effort to create shared understanding from different perspectives is required. She concludes that higher levels of interfunctional communication occur more often in successful product development projects and diminished communications exist in failed projects.

Morelli *et al.* (1995) argued that patterns of communication are dependent on the organisational structure and the project type. They define three general types of communication that are applicable to product development organisations: a) the coordination-type, where technical information is communicated between the team members in order to coordinate their tasks, b) the knowledge-type, where members remain focused in their field but consult with one another, and c) the inspiration-type, which tends to create motivation and inspiration on the team members, thus is more managerial than technical one.

Decisions in this area also concern the measurement of the project performance. The main purpose is to measure the inputs to the product development process, the changes throughout the process, and the output from the process (Griffin, 1993). Griffin presented several measurement rates that could be used for the purpose of project performance, as the author emphasised the need for the firms to know where they are and where they are trying to go.

The last decision to be made, concerning the product development organisation, deals with the selection of the type of the development process. Several models have been developed as options to this decision. The Stage-Gate approach (see Figure 2), developed by Cooper (1993), introduces several review points during the product development process, in which the new product creation might be continued or aborted. MacCormack (2001) presents the evolution of the development processes for software products, from a sequential form called 'Waterfall Model' to an iterative approach with actual testing from the customers called 'Evolutionary-Delivery Model', and the ways these processes have been applied to specific commercial software products. In their article, Ward *et al.* (1995) describe the so-called 'Second Toyota Paradox', where they describe Toyota's unique development process and their ability to design better cars faster and cheaper by delaying decisions and by pursuing excessive numbers of prototypes.

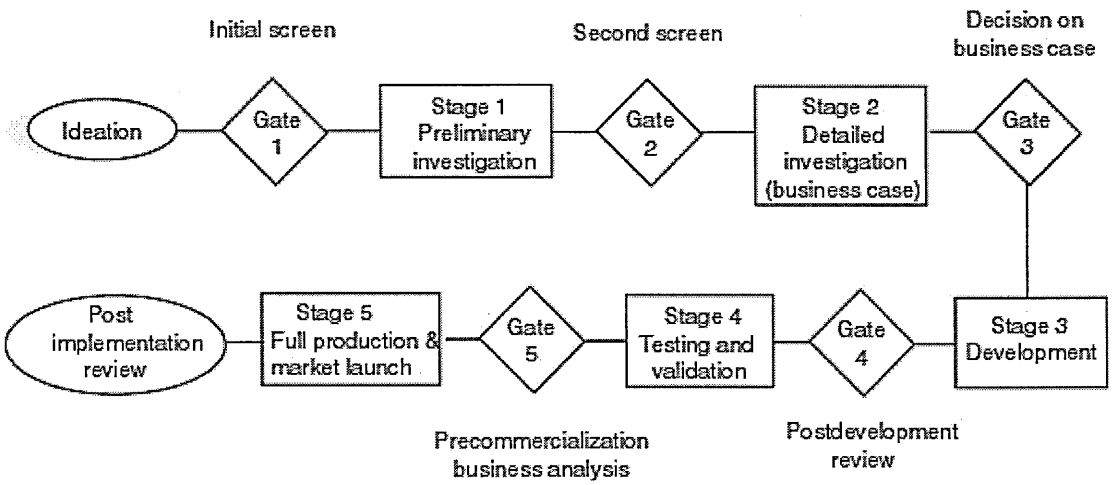

Figure 2: The Sate-gate process model (Cooper, 1993)

2.7.1.3. Project Management

When managing a product development project, the relative priority of the development objectives, timing and sequence of activities has to be established. Thereby, the decisions here can be formed as: What is the relative priority of development objectives? What is the planned timing and sequence of development activities? What are the major project milestones and planned prototypes? What will be the communication mechanisms among team members? How will the project be monitored and controlled?

Common measures of the product development performance include the lead time to develop the product, the manufacturing cost of the products, the cost of the

development effort, and the quality of the final product or its attractiveness in the market (Iansiti and Clark, 1994; Griffin, 1997). However, it is not always possible to achieve high performance on all of these measures at the same time. Cohen *et al.* (1996) showed that often performance measures are traded-off against each other. Furthermore, the effects performance measures might have on a firm's profit in different markets, as Bayus *et al.* (1997) found out for the Personal Digital Assistant Industry, indicate that it is not always appropriate to force-fit one performance measure (such as minimizing the lead-time) on the others to all product development situations. The choice of the right performance measure is a trade-off among time to market, product performance, and development costs (ibid.).

Smith and Eppinger (1997a; 1997b) further developed a tool called 'Design Structure Matrix', originated by Stewart (1981), for the complex procedure of design iteration, that is the repetition of design tasks due to the arrival or discovery of new information. This model, with this unique feature that distinguishes it from the traditional Program Evaluation and Review Technique (PERT) and CPM scheduling techniques (extensively used in product development teams), can facilitate the exchange of information among product development professionals.

There are several techniques employed for minimizing the product development lead-time (Millson, Raj and Wilemon, 1992). One of them, the overlapping of coupled development tasks, often called *concurrent engineering*, is based on the use of preliminary designs and regarded as inherently risky (AitSahlia, Johnson and Will, 1995; Krishnan, Eppinger and Whitney, 1997; Terwiesch and Loch, 1999). Other researchers (Iansiti, 1995a; Kalyanaram and Krishnan, 1997) go beyond the overlapping of coupled development tasks to the overlapping of stages in new product development – the joint evolution of system and technology, of a product's concept and of its detailed design – especially applied in turbulent environments, where flexibility is necessary in order to respond to changing market requirements.

Another decision to be made is the type and extent of communication during the development activities. The so-called *cross-functional communication*, which is the communication between different functions inside a firm (e.g. marketing and manufacturing), is viewed positively from the academic community (Hise *et al.*, 1990; Moenaert *et al.*, 1994; Griffin and Hauser, 1996). However, Moenaert *et al.* (1994) emphasise that the only innovation plan that works correctly in an organization is the plan the same organization has developed to meet its own specific needs.

The last decision to be made at this level is the frequency and timing of project monitoring and intervention. Ha and Porteus (1995) made an effort to model the balance between too frequent reviews and inadequate reviewing. However, research in this area of product development is rather limited.

When all these decisions have been answered, the product development process begins. When focusing on the single product development project, one can identify the following broad category of decisions.

2.7.2. Decisions Made Within A NPD Project

This second category includes the decisions related to a single product development project, which can be further divided into four categories (Krishnan and Ulrich, 1998): *concept development*, *supply chain design*, *product design*, and *production ramp-up and launch*. These categories will be explained in the next paragraphs.

2.7.2.1. Concept Development

The concept development stage is when the product is not only specified (physical configuration) but also the firm selects the extended product-service offering for the lifecycle of the product (Gu and Sosale, 1999). The decisions that need to be taken at that stage are: What are the target values of the product attributes, including price? What will be the product concept? What variants of the product will be offered? What is the product architecture? And, what will be the overall physical form and industrial design of the product?

One way to represent a product is as a vector of attributes (e.g. price, capacity, reliability). Such attributes refer both to the customer needs (or customer requirements) and product specifications (also referred to as engineering characteristics or technical specifications). Conjoint analysis could be used as one structured approach in order to determine the optimal target values of these attributes (Green and Srinivasan, 1990). The 'House of Quality', a tool developed by Hauser and Clausing (1988), is a conceptual map, which aims to establish clear relationships between customer needs and the product specifications and to convey these to the manufacturing function of the firm. Ramaswamy and Ulrich (1993) tried to address some of the trade-offs required in real design problems by augmenting the above tool with engineer models, which are set of equations that relate the design variables to the product's performance metrics. A hybrid methodology, which is developed by Srinivasan *et al.* (1997), supplements those methods with realistic physical prototypes in order to collect consumer preference information.

In addition to the attributes, which offer a limited view of the product, concept development includes the *core product concept*, which is the embodiment of these attributes into some technological approach. Two more focused activities support this decision: concept generation and concept selection (Ulrich and Eppinger, 2000). In their book, Ulrich and Eppinger suggest that multiple concepts from a variety of sources should be considered for the new product.

Although the traditional approach during concept selection is to freeze the concept before the product design commences, Bacon *et al.* (1994) found that it is necessary to be able to respond to changes in the concept, as required from the market, especially in dynamic environments. Several researchers argue that it is optimal to pursue several concepts, and select the best design and finalise the specifications later in the process (Srinivasan, Lovejoy and Beach, 1997; Bhattacharya, Krishnan and Mahajan, 1998).

In order for the product to address a variety of consumer preferences, a firm might offer several product variants to the marketplace. Kekre and Srinivasan (1990) found that product variety positively links with market share benefits and overall

profitability. However, this must be balanced with the economies of standardisation in design and production (DeGroote, 1994).

A closely related decision is the selection of the components that are going to be shared across products in a firm's portfolio. Whitney (1993) presented a successful use of component sharing across products in a Japanese manufacturer of automotive components. The ability to share components, however, is determined in part by the *product architecture*, which is the allocation of a product's functionality to physical components (Ulrich and Eppinger, 2000). Research on product architecture has focused on operations and marketing issues (Ulrich, 1995; Nobelius and Sundgren, 1998) and the organisation design (Sanchez and Mahoney, 1996). One of the most important characteristics of the product architecture is the modularity, which has received recently attention from both academics and practitioners (Baldwin and Clark, 1997; Gu and Sosale, 1999).

The last stage to bring a product concept to life is to select the physical form and appearance of the product (Ulrich and Eppinger, 2000). This selection is part of an activity called *industrial design*. It is important to note that, although it has an impact upon the customer preferences (Yamamoto and Lambert, 1994), industrial design has drawn little attention by the researchers.

2.7.2.2. Supply Chain Design

The supply chain decisions include issues related to the supplier selection as well as issues related to the design of the production and distribution systems. Here, the decisions to be taken are: Which components will be designed specifically for the product? Who will design and produce the product? What is the configuration of the physical supply chain? What type of process will be used to assemble the product? Who will develop and supply the process equipment?

Most of the products contain a mixture of components, those designed specifically for the product and standard components. The selection between the two is depended on the benefits for the firm (Ulrich and Ellison, 1999; Maffin and Braiden, 2001). Clark (1989) investigated the impact of using off-the-self parts and of involving suppliers in the product development and found significant differences between the approaches used in the U.S, Europe and Japan. Ulrich and Ellison (1999) found that when the customer requirements arise in a complex way (holistic customer requirements), it is more likely to design the components of the product. In this situation, another decision to be made is who will design these components. In another study, the authors argue that these decisions should be made jointly, because of the interdependencies between pairs of design and production activities (Ulrich and Ellison, 1998). The nature of these decisions is closely related to the classic *make-buy decision* (Mahoney, 1992).

2.7.2.3. Product Design

The product design phase is the specification of design parameters, the determination of the assembly process and the detailed design of components, together with their materials and their production process (Krishnan and Ulrich, 1998). Bills of materials, geometric design and production guidelines are frequently a result of that phase. The

decisions here are: What are the values of the key design parameters? What is the configuration of the components and assembly precedence relations? What is the detailed design of the components, including material and process selection? All these decisions generally result in geometric models of assemblies and components, a bill of materials, and control documentation for production.

The first phase is the parametric design phase, where the values of design parameters are decided in order to satisfy and/or optimise some design performance characteristics. This phase is performed after establishing the basic product concept, where it is feasible to create a mathematical model of product performance. The body of literature related to the use of mathematical programming approaches to solve parametric design problems is relatively large. Nevertheless, Papalambros (1995), in an overview article of the literature, noted that there is a gap between theory and practice, and the optimal design in industry is a result of several trial and error efforts with engineering models.

Boothroyd *et al.* (1994) provided a methodology for designing components for easier assembly. The idea behind this methodology is to refine a design using a metric of assembly performance, such as the assembly time, to provide feedback on the quality of the design. However, Ulrich *et al.* (1993) note that the use of design guidelines should be made with caution, as most of the design-for-manufacturing rules tend to emphasise short-term improvements, which in turn might not have positive impact on the profitability. They suggest the inclusion of strategic and market implications of the design and the production costs when reviewing a product's design.

2.7.2.4. Production and Launch

The last category of the decisions related to a single product development project is those decisions related to the production and the product launch to the marketplace. Two questions that rise here are: What is the plan for market testing and launch? What is the plan for production ramp-up? A considerable marketing literature exists from the marketing perspective, concerning the first question (Mahajan and Wind, 1992; Rackham, 1998; Benedetto, 1999). Kalish and Lilien (1986) discuss the trade-offs for the launch decision, as it is affected by multiple factors including competitor entry to the market and the completeness of the product development. Hendricks and Singhal (1997) argue that it is essential for the firm to meet the announced new product introduction date, otherwise the market value of the firm decreases significantly. It is important to note, at this stage, that there has been limited research on the effect of poor product design decision making on the production of the final product. Practice, though, shows that poor product design decisions can reduce the rate of production ramp-up.

However, this bulk of literature on new product development presented no evaluation of product support during new product development.

2.8. Summary of the Product Support and NPD Literature

Customers are becoming more demanding in terms of more economical and efficient product support from the manufacturers (Loomba, 1996). Lele (1986) argues that a key factor, influencing both the cost and the efficiency of product support, is the product design. According to several researchers, the most important decisions are

being made at the design stage of the new product development process (Teresko, 1994; Gu and Sosale, 1999). Although support requirements should be among those decisions (Armistead and Clark, 1992; Teresko, 1994; Cespedes, 1995; Galloway, 1996; Goffin, 1998), Goffin (1998) found that product support is often ignored during the new product development process.

The product design can influence the ability to offer product support in several ways:

i. It influences the amount of support necessary for the product. For example, the product reliability and the maintenance and repair required are mainly dependent on the product design decisions (Lele, 1986). Moreover, the use of diagnostics (Hegde and Kubat, 1989) and modular product design can reduce the repair costs of a product (Mathe, 1986; Karmarkar and Kubat, 1987; Hull and Cox, 1994; Lele, 1997; Gu and Sosale, 1999).
ii. It influences the selection of the means used for the delivery of the product support (Sleeter, 1991). The design of the product might improve or distract the access to critical parts, making their support either easy or time and labour consuming. For example, the cooling system in Caterpillar's new skid-steer loaders has been simplified, improving the access to the engine required for daily checking and maintenance (Mercer, 1999).
iii. It influences the amount of user training needed (Mathe, 1986; Athaide, Meyers and Wilemon, 1996; Anagnostopoulos, Goffin and Szwejczewski, 2001). Some companies design their products specifically to be easier for the users to operate, thus reducing the necessary user training.
iv. It influences the ease of upgrading (Davidow, 1986; Lele, 1997). Modular design is an example of product design for easy upgrading, as the modules could be changed easily, under the condition that the connection with the main platform remains the same (Ulrich and Eppinger, 2000).
v. It influences the spare parts inventory control for durable products (Lee, 1996; Nobelius and Sundgren, 1998; Knezevic, 1999).

Product design, therefore, can reduce the total cost-of-ownership, which is the cost of maintaining the equipment over its working lifetime (Blanchard, 1991; Knezevic, 1999). Several researchers argue that, when a new product is designed for easy product support, it can have a strong differentiating factor on the market (Mathe, 1986; Swink, Sandvig and Mabert, 1996).

In a very recent article, Goffin and New (2001) gave a useful table of the literature covering product support in the NPD process. Adopting that table and adding some additional articles found relevant in that area, the following table (Table 2) was created.

	Article	Type of Article / Methodology	Industry(s)	Sample	Key Points
1	Livingston, 1988	Practitioner conference presentation on design for service.	Photo-copiers (B2B)	Rank-Xerox	Rank-Xerox perform a detailed evaluation of support requirements at the design stage Total lifetime costs are determined Clear design goals are set for all aspects of support
2	Hull and Cox, 1994	Journal paper with in-depth case studies. Purposive sample of six companies. Main focus on field support but mentions DFS issues.	Electronics and computing (B2B)	Amdahl, AT&T Hewlett-Packard, GE, IBM and NCR	'Leading' companies consider support during NPD. For example, at IBM 'field service personnel... perform an important role as serviceability advocates' and at NCR 'maintainability and serviceability of products are a prime consideration in the design'
3	Teresko, 1994	Trade journal description of software for design for service developed with a consortium of companies.	Electronics, automobiles and plant equipment (B2B)	Caterpillar Chrysler Ford Hewlett-Packard	Ease-of-manufacture, ease-of-service and recycling of products are inter-related All aspects need to be considered at the design stage A software package for this purpose was developed with a consortium of five companies
4	Galloway, 1996	Journal article with a description of the procedures for military procurement and the need for appropriately designed products.	Defence (B2B)	US / UK defence	Defence equipment has particularly strong service and support requirements Defence DFS needs to cover maintenance, repair, documentation, training of personnel, etc.
5	Goffin, 1998	Journal paper with a survey of design for supportability at high-tech companies / single case study.	Electronics / medical electronics (B2B)	Trade association / Hewlett-Packard	At many companies support is not considered until well into NPD Importance of understanding cost-of-ownership Key role of support-related design goals.
6	Knezevic, 1999	Journal article with a single descriptive case study.	Aerospace (B2B)	Boeing	An organizational change was necessary (creation of the "chief mechanic" position). They used quantitative goals for reliability and availability. Boeing had a close cooperation with their suppliers during the NPD. Team-working and direct customer input were used during the design stage.
7	Goffin and New, 2001	Journal paper with five (disguised) case studies based on multiple interviews, documentation, inspection of products and triangulation of data.	Telecommunications, automobiles, vending machines, aerospace, domestic appliances (B2B/B2C)	'Leading companies' in various sectors	Difference in the importance of product support elements. Different degrees of evaluating the support needs. Automotive and aerospace cases presented the involvement of field support specialists in the NPD. No company showed fully recognition of product support to its business.
8	Ivory, et al 2003	Journal paper with two case studies with "extensive and detailed interviews" but no mention of any analysis of company documentation.	Transport and materials handling (B2B)	Alstrom transport; Clarke Chapman handling systems	Capital projects have major requirements for maintainability, which go beyond those of the individual products involved Achieving high maintainability requires timely cooperation between all of the organizations involved in the project
9	Markeset and Kumar, 2003	Journal paper with a single case with an element of action research.	Automated production systems	Unknown	Cross-functional communication difficulties were found to hinder Design For Support

		Very few details of methodology given.	(B2B)		Employees need to be trained on the importance of the reliability, availability, maintainability and supportability of equipment.
10	Fites, 1996	Journal paper with a single case.	Earth moving equipment (B2B)	Caterpillar	Design products to eradicate failure (e.g. components that are likely to fail are duplicated). Design serviceability into all products (make all products easy to service).
11	Iozon and Holmqvist, 2005	Conference paper with eight cases. No mention of any analysis of company documentation.	Production equipment, construction equipment, lifting and transport equipment, vehicles, railway systems (B2B)	Business to business sector and a product development base in Sweden.	Only two of the firms had service requirements included in the development specification. Only one company was managing and controlling the service requirements in a systematic way during the product development process.

Table 2: Previous Literature on Evaluating Product Support During NPD

Livingston described how Rank-Xerox focused on low product cost-of-ownership (Livingston, 1988) and adopted of a range of design goals covering ease-of-use, ease-of-cleaning, easier maintenance, and ease-of-repair. Rank-Xerox found it necessary to clearly set design priorities, as different functional departments may have opposing objectives. The limitations of Livingston's article is that only one company's approach is discussed, and the analysis is purely descriptive.

Hull and Cox (1994) conducted case study research at six leading electronics manufacturers. They focused on these companies' customer support organizations but also identified the importance of DFS. For example at National Cash Register (NCR), 'maintainability and serviceability of products are a prime consideration in the design and manufacturing processes'. Similar approaches were found at the other case companies, American Telephone and Telegraph (AT&T), where 'products are designed for serviceability and [good] after-sales support is acknowledged as a prerequisite for product sales'. Although they clearly identified that leading electronics companies consider support at the design stage, Hull and Cox gave few details.

Teresko (1994) considered serviceability and its contribution to competitiveness. The article discusses a software package that identifies service costs. The apparent limitation of the software is that it focuses on maintenance and repair and ignores the other elements of customer support, such as user training and documentation. The article is also purely descriptive.

The cost-of-ownership of military equipment, such as helicopters, can be very high and so DFS is important. Galloway (1996) describes the different issues that governments need to consider before they purchase new military hardware and emphasizes the need for defence equipment manufacturers to adopt DFS. Unfortunately, Galloway's article only describes procurement and not how manufacturers should use DFS. However, it is obvious that military equipment has particularly strong service and support needs, due to the long and demanding use cycles.

Goffin (1998) used a survey of a professional association to look at how companies plan DFS. It found that support requirements are typically not considered early enough during NPD and few companies use quantitative goals. The second part of the paper was a case study of a medical product. This found that support may have to 'compete' for resources with issues such as product features during NPD and so a clear understanding of the cost-of-ownership is required. The main limitations of this research are the low response rate to the survey and that a detailed investigation was made of only a single company.

Knezevic (1999) described how Boeing designed the 777 airliner to maximize the schedule reliability of airlines. Although this is a purely descriptive single case, with associated limitations, it indicates the importance of quantitative design goals being used for service and support issues. Details of the goals set and the results achieved in the project give us insights, as does the discussion of the importance of top management attention, if DFS is to be successfully adopted by an organization.

Five case studies discuss DFS in a range of industries and there were several key findings (Goffin and New, 2001). Firstly, different elements of support are more important for certain products. Secondly the level of evaluation of service and support

at the design stage varied widely between the case companies and the use of quantitative goals at the design stage appeared to lead to better products, in terms of their *supportability*. Finally, the cross-case analysis showed that strong management commitment helps drive the consideration of service and support requirements at the design stage. The limitation of Goffin and New's paper is that it took a cross-sectional approach and did not investigate how the different design decisions affect supportability.

Ivory *et al.* (2003) studied a railway system and a materials handling system. Both projects were found to have significant maintainability requirements, which go beyond those of the individual products involved. Therefore, to ensure an effective system, timely and effective cooperation between all of the organizations involved is necessary. The limitation of this study is that it appears to have focused only on interview data, with no triangulation.

A descriptive case on the earth-moving equipment manufacturer Caterpillar demonstrated how after-sales service can play a key role (Fites, 1996; Mercer, 1999). The company's products are normally rented out by their owners to building projects (i.e. plant hire) at an hourly charge and so any breakdown—*downtime*—leads to a loss of revenue. To minimize this risk, Caterpillar designs products to eradicate failure and to offer customers what the company terms 'negative downtime'. This has four main aspects. Firstly, the components that are likely to fail are duplicated so that a single component failure will not stop a machine working. Secondly, advanced diagnostics programmes constantly monitor a product's performance. Thirdly, earth-movers are connected via advanced telecommunications networks to Caterpillar and when a component fails (and the duplicate component takes over) this is automatically notified. Finally, service engineers will replace the failed component at a time that does not inconvenience the owner. In this way, the downtime is 'negative' because the first time the owner hears about a failure is when it already have been solved. The Caterpillar Company designs *serviceability* into all of its products (serviceability is the ease with which a product can be serviced) and strongly promotes the advantages this brings to customers in its advertising.

Markeset and Kumar (2003) looked at the introduction of DFS ideas into a manufacturing company and showed that cross-functional communication problems hindered DFS and R&D engineers needed to be trained on the importance of the reliability and supportability of equipment. The limitations of this study are that the trail of evidence is sparse and the researchers did not take the opportunity to build on the case study methodology of previous studies.

The last empirical study to date is a multiple case study by Ionzon and Holmqvist (2005). They looked at the integration of service aspects into NPD at eight B2B companies in Sweden. They found that only two (of the eight) companies had a service requirement included in the development specifications and only one firm managed the requirements in a systematic way. At most of the companies the service personnel were not involved in NPD.

From this literature review, several gaps have been found to exist in this area and will be explained in the following section.

2.9. Gaps

Research in product support and NPD is at the level of exploration, and many gaps are still available for research in this area (Hull and Cox, 1994; Goffin and New, 2001). Those gaps are summarised into the next points:

1. Goffin (1998) and Hull and Cox (1994) suggest that more case studies should be conducted in order to understand better the complexity of evaluating product support during the development of new products. Goffin also proposes the investigation of product support in both high- and low-tech equipment manufacturers. Such a study will reveal the role of support in NPD in areas where it is an essential element of marketing and in areas where it is not. For example, there is no indication of a proportional percentage of companies in different industrial settings that use product support as a competitive advantage, taking into account metrics of overall business performance (return on investment, market share, sales growth) or product success.
2. Research on product support and NPD has been conducted in several industries, including automotive, electronics, computing, vendor machines, automotive and plant equipment. However, product support needs to be investigated in other industrial settings like the software industry (where it is important). A comparative research investigating the key steps in the development and implementation of product support in new products by different manufacturing organisations can also be conducted based on these case studies, in order to obtain a panoramic (holistic) view on this issue.
3. The survey conducted by Goffin (1998) in 1989-1990 had a small response rate, revealing the need for the conduct of a similar survey, targeting to a more representative sample and more up-to-date information. Hull and Cox (1994) also emphasise the need for a survey to be conducted in the area of product support, in order to expand the limited focus of the case studies already conducted.
4. The literature published in the area of customer satisfaction does not cover the role of product support in the satisfaction of the customers (Kekre, Krishnan and Srinivasan, 1995). An investigation of buyers' (clients) expectations/needs of product support for different types of products (or industries) is essential in order to understand better what are customers' requirements of support.
5. Goffin and New (2001) argue that there has been no investigation of whether products that are designed for easier support actually achieve their targets (e.g. in reducing the cost-of-ownership). From the literature research I identified that there has been no investigation on how product design affects the quality of product support provided. As a consequence, the process and/or guidelines for introducing product support through 'Design for Supportability' in new products have not been identified. Descriptive goals/measures for introducing product support in new product development are required.
6. There has been no formal description of how customers' support requirements are investigated and recorded by product support organisations in different companies (Davenport and Klahr, 1998). Research on the transfer of knowledge on product support from the product support function to the marketing and manufacturing functions is also needed.

2.10. Summary

In this chapter, a review of the literature published in the areas of product support and NPD was presented in order to reveal potential directions for this research. It was found that many gaps exist in the area and much work still needs to be done in order to fully understand the mechanisms of involving product support in the new product development process and the implications of doing so. In the following chapter, the research questions to be investigated will be presented, together with the methodology that will be used to explore them.

CHAPTER 3. METHODOLOGY

3.1. Introduction

In this chapter, the methodology followed in this research will be explained in detail. It will include the following sections:

- Research questions, which will include all the available research methods considered for investigating them
- Case study, in which all detailed regarding the data collection and analysis will be explained, and
- Cross-case analysis, in which the basis of the cross-case analysis will be given

3.2. Research Questions

This research will explore how the product support is incorporated in the NPD process by manufacturers. This leads to the following research questions:

Question 1: How are product support requirements incorporated in the new product development processes in companies in several industrial sectors?

Question 2: At what stage of the NPD process is product support providing their input?

These research questions are based on the gaps found in the literature mentioned above, and on the proposals for future research by the authors in the field. They could be investigated through the use of various research methods (Fowler Jr, 1984; Yin, 1994; Sapsford, 1999; Reason and Bradbury, 2001; Voss, Tsikriktsis and Frohlich, 2002), such as:

a. Action research

b. Case study research

c. Survey research

The advantages and disadvantages of each research method, together with their implications for my research, are presented in detail in Appendix 1 and so here onlythe most important points will be discussed. Action Research was considered an option in investigating the two research questions in that it would allow for a detailed look of all the stages of the new product development (NPD) in a company. An industrial product would have been selected and all the process followed to develop it would be examined carefully through the use of various sources: documentation, participation on all the meetings of the development team, and short interviews will the NPD and product support managers. However, it was not chosen because this would involve a study of one to two product developments in a company. Most industrial products take more than a year to develop (from initial concept to final launch), with some requiring up to 10 years (Ulrich and Eppinger, 2000). By consequence, it would have been unrealistic to undertake such an extended fieldwork in the limited time frame of an MPhil work.

The survey research was also considered as a methodological approach. It is a quantitative method that deals with large samples and broad sweeping of a topic thus increasing generalisability (Fowler Jr, 1984). However, in order to succeed increasing the generalisability and because of the limited cases available in the bibliography, it

would be necessary for the survey to follow a case study research approach that would have been dealing in detail with the phenomena in question. Time restrictions and access to relevant associations were the main obstacles in applying the survey methodology to this research project.

The case study research was considered a more appropriate methodological option. Each of these approaches offers a different insight and perspective on issues relating to the implementation of product support in the new product development process. Case study allows for a qualitative and detailed investigation of the issue but is very much context specific (Yin, 1994) (for measures of quality of case study research see Appendix 2). The case study method will be used to investigate both research questions.

The final research design, as illustrated in Figure 3, shows the case sample selection (number of companies and sectors) and the data to be collected.

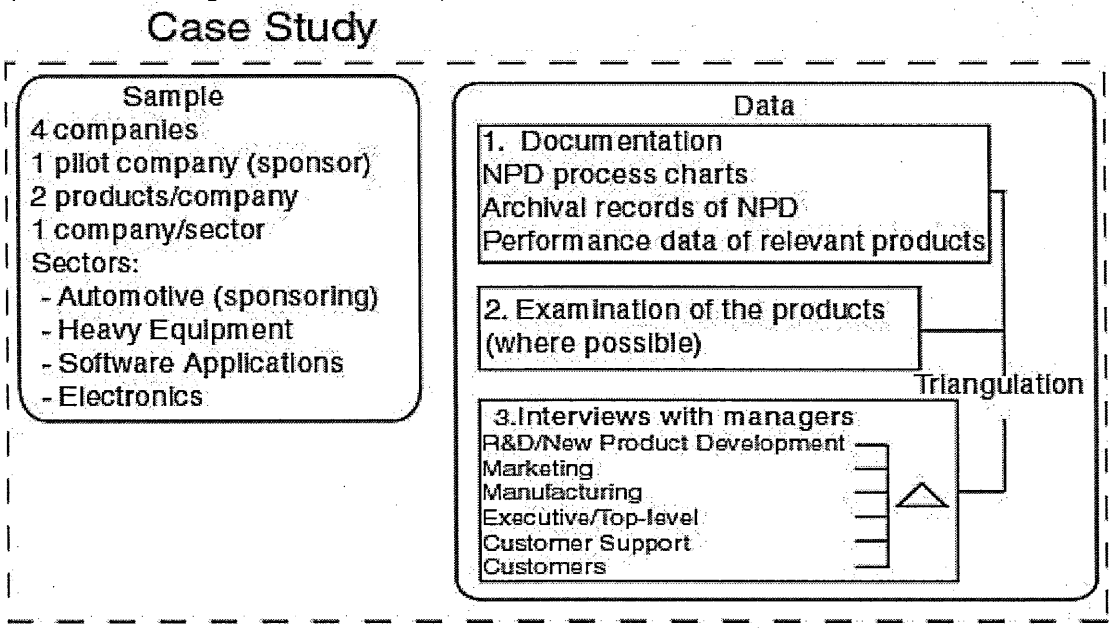

Figure 3: Research Design

3.3. Case Study

Case study is a particularly useful methodology when *investigating "a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident*" (Yin, 1994). In this case the phenomenon being the implementation of product support and the context being the actual NPD process used by a company.

The starting point of my methodology will be the in-depth investigation of the actual process of new product development for business-to-business products (B2B). In particular, the case study research aims to identify:

(a) The point in the process where the product support was taken into account and the related decisions,

(b) How this was accomplished (e.g. design goals, maintenance goals, qualitative or quantitative),

(c) Who was in charge of deciding these goals and their implementation,

(d) What were the trade-offs at the product development (e.g. easier to support or easier to sell?) and

(e) What was the quality of product support in the field.

The diagram below (Figure 4) illustrates, step by step, the methodological blueprint of a case study process from the case study protocol to the cross-case analysis.

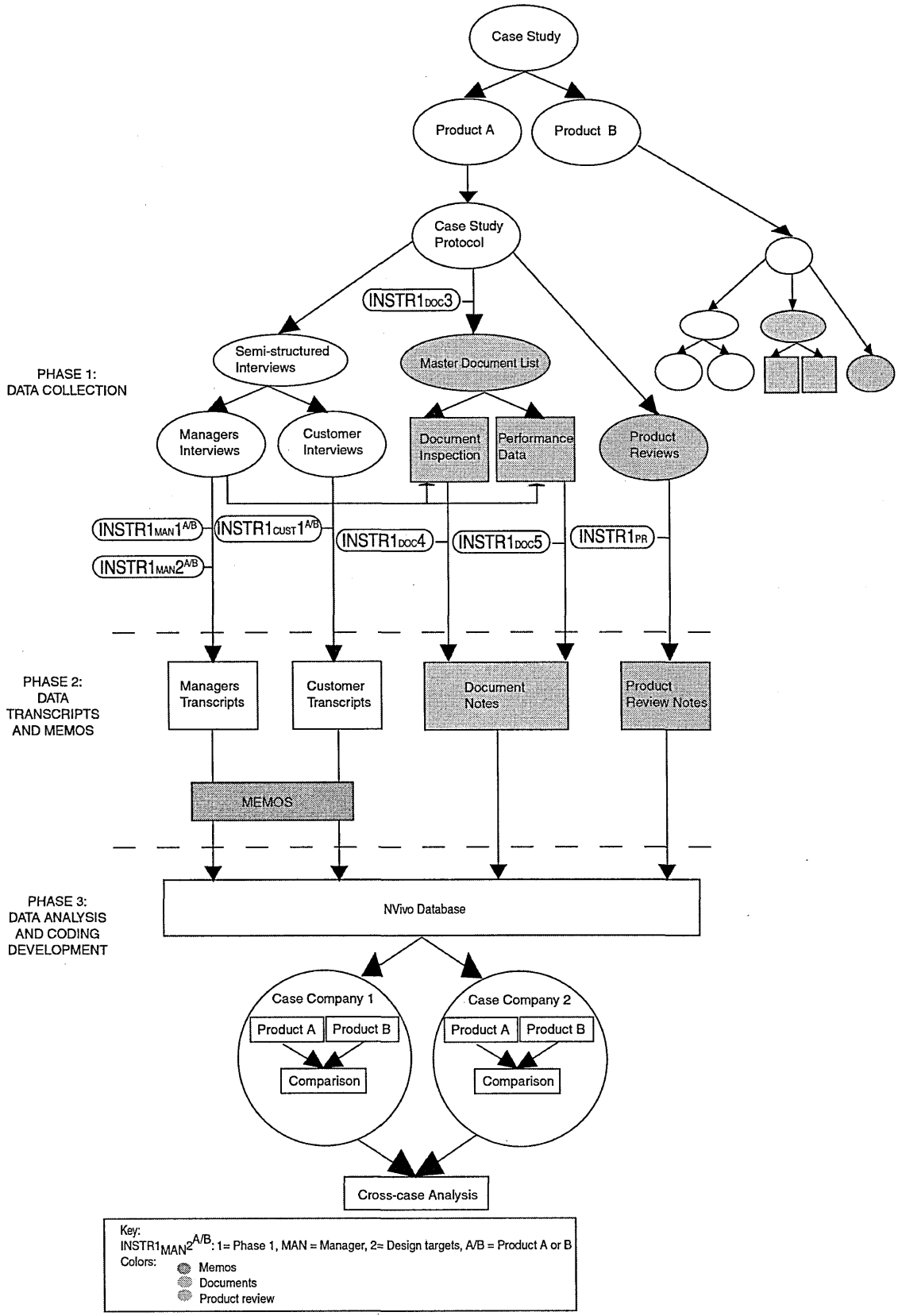

Figure 4: Data Collection and Data Analysis in NVivo

The case study protocol design contains the procedures and general rules that should be followed in conducting the research in different cases. Five main sources will be used for the data collection (Phase 1):

a) Semi-structured interviews with managers
b) Semi-structured interviews with a key customer
c) Documents regarding the NPD process and other related issues
d) Performance data collected from Post-launch Documents
e) Product review interview with one manager from the product support department

For each data source, instruments will be used to ensure that the data is collected systematically. From each source, transcripts and notes will be taken (Phase 2) to assist data analysis with NVivo (Phase 3). The last step of the data analysis involves comparing the two products in each case, which will set the stage for a cross-case analysis. Each phase in the Case Study research will be further discussed in the following sections.

3.3.1. Phases of the Case Study Protocol Design

3.3.1.1 Phase 1: Data collection

In Phase 1, multiple sources for data collection were employed. Using multiple sources of evidence (i.e. checking the informants' views against company documentation) to investigate the same problem will help provide data triangulation (Voss, Tsikriktsis and Frohlich, 2002).

3.3.1.1.1. Product selection and product review

Two similar B2B products that differ in the amount of product support required after the sale will be selected in the company. The reason behind this selection is that this study will try to compare the processes used for the development of these two products and to identify potential differences in the approaches used, focusing on the input of the product support managers. A product that is difficult to support has one or more of the following characteristics:

- The installation of the product is difficult to conduct.
- The basic maintenance (service) for the product cannot be performed by the user or takes a long time to perform, due to the complexity of the product.
- The frequency of repairs is high, because the product reliability is low.
- The product's failure rates are high, due to poor reliability

Consequently, the product that is easy to support performs better than the product that is difficult to support in one or more of the above areas.

The selection of the two products will be based on three types of data:

a. Opinion(s) of service manager(s)
b. Product review. Key differences in the products will be identified with the assistance of a service engineer. The latter, with product support in mind and with the help of the product review instrument ($INSTR1_{PR}$, see

Appendix 3) will help identify the key differences in the products. Particular attention will be given to design concepts that ease or hinder the serviceability of the products.

c. Data about the performance of each of the candidate products on several product support elements. The main focus will be on reliability, maintenance, repair and cost of ownership elements.

After identifying the two products, I will have to trace the managers involved in the development of these products, inside the company, and conduct interviews regarding the involvement of product support in the NPD process.

3.3.1.1.2. Semi-Structured interviews

Semi-structured interviews with the company managers and a key customer will be conducted with a fairly closed framework. The interviews will be guided only in the sense that some form of interview guide (e.g. guideline questions and interview instruments) will be prepared beforehand. Semi-structured interviews will allow for focused, conversational communication but will also give the flexibility to both the interviewer and the person being interviewed to ask for clarifications and probe for details (Brown and Dowling, 1998). Particularly when using the interview instruments, in an effort to increase the depth of the dialog conducted, the interviewees will be prompted to support their answers.

3.3.1.1.2.1. Interviews with managers

In order to reveal a cross-functional picture of the NPD process, semi-structured interviews will be carried out with managers involved in the development of new products, from different departments inside a company. The managerial positions and the content of the interviews are presented in Appendix 4.

Among the instruments to be used with the company managers are the following:

- $INSTR1_{MAN}1^{A/B}$: This instrument contains questions regarding the perceived importance of the product support elements to the customers, the product support performance of the products in the market, the involvement of product support in the current NPD process and the processes that were used for the development of both products A and B (see Appendix 5 for details). All managers interviewed will have to provide info for this instrument.
- $INSTR1_{MAN}2^{A/B}$: This instrument is used for the collection of quantitative product support targets used for the design of both products A and B from the product support department (Appendix 6).

3.3.1.1.2.2. Interviews with customers

The experiences of the case companies' managers with the two products will be complemented by interviews with one key customer of each product. These interviews aim to explore the experiences of the customer company with the products and the level of product support they received from the company under investigation. There are obvious limitations to only interviewing one external customer but this extremely limited sample size was due to the limited scope and the time available.

The instrument that will be used with the customer is the $INSTR1_{CUST}1^{A/B}$. This instrument concerns the importance of the product support elements to the customers and the product support performance of both products A and B in the marketplace (details in Appendix 7).

3.3.1.1.2.3. Master document list

This is an instrument, coded $INSTR1_{DOC}3$, that will be employed in the collection of the documentary evidence. It consists of a list of company documents that have to be reviewed or collected from the cases. The list was based on the literature (Goffin, 1998; Ulrich and Eppinger, 2000) and the researcher's previous experience. Examples of such documents are:

- Documents in critical decision points during the NPD process and related to the product development, the product support involvement and the product support provision in the field
- Minutes from meetings during the product development projects
- Design goals, like failure rates, repair time, training time etc.
- Performance data of the products on reliability, maintenance, repair and cost of ownership.

A complete list of documents is provided in Appendix 8. When it will not be possible to copy some of the documents, the instrument $INSTR1_{DOC}4$ will be used to record the documents on-site. This is a recording pro-forma that requires the researcher to record the name of the documents, their size, the authors and interesting quotes regarding the NPD process and the product support. The pro-forma is included in Appendix 9. An additional pro-forma will be used to record the performance data from the company's documents ($INSTR1_{DOC}5$ in Appendix 10).

3.3.1.1.2.4. Product review interview

The product review interview ($INSTR1_{PR}$) is a list of questions to ask during the product reviews with the engineers or product support managers in the companies and is presented in Appendix 3.

3.3.1.2. Phase 2: Data transcripts and memos

In this phase, transcripts were generated from the interviews and the documents and product review notes in the qualitative data analysis software QSR NVivo. In the case of the interviews' transcripts, I find it useful to generate tables with quotes and memos on the key elements of the transcribed data. These structures prove to be particularly helpful with the data analysis when using NVivo.

An example of such a tabular form with the managers' interview quotes on the involvement of product support in each NPD stage is shown below (Table 3). This table has enabled me to pull out some of the main categories when coding the interview data, as illustrated in the section 3.3.2.1.

Stages / Positions	Customer Support	NPD	Marketing	Manufacturing	Strategy
Testing and Validation	- Design for Support: Personally I think it was a lot more than the Product A, 'cause we were involved in for example the air dryer, the serviceability of it, how quick it takes you to change the pump in the machine, we've been through the validation to check all that, so it is a lot better - so it was taken more into consideration when we designed the machine - it was with thoughts of being able to service it and it actually involved the service team and service people to come in and try out their design and if anything was wrong they would then, as it happened with the fan, look at the design to accommodate the service. - during the validation we couldn't change it in one hour and a half later and we decided we couldn't do it, and the design was changed **- It was still later on, it was still 'here is the product'**, at least they listened before it went out I guess - if you say it was 2 years of development, **it was 6 months before launch** - I think there was not any actual goals in terms you should actually service it in the X amount of time, or have X amount of time between services. Maybe that pump life, that was something it was talked about a lot, there was an expectation but that was only to meet what was actually there on the existing product - we are involved there in testing, documentation, liaison with the field if it needs to, not so much on the design because it was just shown to us effectively, this is what we are going to do. We are more let's see what we've got, can we put more on service, testing…	- In this particular case, the development team did initial testing but then we did a validation exercise where we had a new validation plant and we had a group of people taking the place of the customer. So no paying customers saw the machine until it was launched. - Prototype is normally ready after 12 months. - Did you have the product support participating in the development of the prototype? No, not really. - They also sign off the validation as well, so I mean that the validation is the most important thing for them, because that confirms that it meets the customer requirements but they would also sign off the development.		- But there was a concurrent team on the project, manufacturing engineering, Group Technical Support, we involved them, which includes product support, obviously they feed in field issues, etc. - Yes, I think as we validated the Product B, it was the first product we properly validated, we had something like 30-60 that would have been tested. That's development testing. After the development they then went into independent validation and part of the validation process is to put the product inside with customers. So say you've got six months of validation, after three months you will be confident enough that it could work well enough that it can work on a customer site - Yes, I think validation have a bugs list or defect log, I think they call it, and as they go through the process they would raise those and they would all be recorded and issues owners have given to them. We would then go back and review that list on a weekly or biweekly basis. - So usually the problems are fairly minor, but they will stress the printer out, and hopefully the development testing has done the same, so you shouldn't really find too much, because you are repeating a lot of the stuff that you've done already. - If there was something happening as a reset, then obviously we had to upgrade the software and re-issue it, but if it was something that was like a square on the screen went black, you might say 'well that might be acceptable for the amount of time that somebody is going to use it to have a black square in screen 125 or something	- it must have been done before or during we were trying to make the product ready for manufacturing. Because there was a lot of feedback from the manufacturing group on how to make things easier, changing cabling links, that sort of stuff, and I know that the Group Technical Support provided a lot of input at that stage as well, to refine the design to make it better for the service engineers.

Table 3: Tabular form created for one stage of a case company

3.3.1.3. Phase 3: Data Analysis – Main stages

The analysis of the case study data will follow the approach recommended by Miles and Huberman (1994). The data analysis will be conducted in four main stages:

1. Each case will be reviewed separately and the data will be analysed to give a complete picture of the company's approach to evaluate product support during the NPD process.
2. Data reduction, the process of selecting, focusing, simplifying, abstracting and transforming the data will be conducted.
3. Following the data reduction, cross-case comparison will be conducted in order to identify any differences and similarities that exist between the cases and to identify a number of best practices (Yin, 1994).
4. Conclusion drawing and verification of the results will be conducted by running workshops with the participating companies. They will provide good opportunities to discuss the findings with the informants.

3.3.2. Data analysis: Coding development

The literature (Miles and Huberman, 1994) recommends that qualitative data coding moves from descriptive to interpretive coding. Qualitative approaches in social research involve data gathering techniques that lead to 'soft' data (e.g. loosely structured interviews and documentary evidence). Performing adequate content analysis to non-quantifiable data is a complex task. In the past, qualitative data has often been limited to the presentation of quotes and passages which if selective is in danger of bias, especially because the data itself has already been fabricated through the researchers selective engagement in a situation (Bliss *et al.*, 1979). To address this limitation, Bliss *et al.* have developed a method for the analysis of large and complex bodies of qualitative research data based on the principles of network analysis. Network analysis has its origins in systemic linguistics, which are interested in the description and representation of meaning (the semantic resources of language) in a system (Kress, 1976 in Bliss *et al.*, 1979).

By a **system** is meant "a finite set of choices in an environment which permits the range of choice". By a **network** is meant "a structure of interdependent options showing by its structure the patterning of related descriptive features, and by the combinations of features it permits the particular complex grouping of features it accounts for and labels with those features. Actual instances of different meanings each correspond to just one configuration of choices out of the possible configurations of paradigms" (Bliss *et al.*, 1979, p.431). Here lies the main difference between systemic and most networks. The former are logically generated oppositions.

In this section, I will illustrate how systemic networks were used in the data analysis process to represent structures of possible features of data. I will provide an example from the analysis of the data regarding the involvement of product support in the NPD process.

3.3.2.1. Example: Involvement of product support in the NPD process

In the original analysis text instances regarding the involvement of product support in the NPD process were categorised in a table according to the stage they were referring to (see Table 3). Such coding is rather simplistic and perhaps of less relevance to the research, for it treats all research data in exactly the same way. The task of analysis, however, is to be able to clearly identify and describe differences in the data in a principled manner (Brown and Dowling, 1998). This involves working intensively through the data and developing descriptive categories. Producing a systemic network is a useful way of organizing these categories.

Further work with the data indicated that text instances referring, for example, to the role of product support in the Testing stage of product B, could be divided to distinguish between 'targets', that is comments about targets used for the evaluation of the product, and 'actions', that is comments about specific activities of product support in that stage. In the 'targets' term a distinction is made between comments that are 'function related', that is comments about whether a product functions in different working environments, and 'product support', that is those that are about the service of the product. The development of the systemic network so far is principally a process of *induction* from the data collected (Brown and Dowling, 1998), in that I have inferred a number of general categories from the critical engagement with particular text instances available in the empirical data. By text instances I do not refer only to data collected from the *interviews* with the managers. At this stage, data from the product review and the company documents were also used to generate categories in the network. For example, the category 'stages' comes from *documentary data* specific to each company, whilst the categories 'product A' and 'product B' refer to a distinction/choice made in the *product reviews*.

In order to develop the analysis further I needed to move into the theoretical field. Product support comments were subdivided to 'Installation', 'Repair', 'Maintenance', 'Usability', 'Upgrades', 'Spare Parts', 'Warranty/Cost of Ownership'. These categories have been *deduced* from Goffin's (1998) theoretical framework. I can now locate all text instances on product support directly into locations on these theoretically generated categories. This completes the development of the network from the Stages/Testing/Product B route, which is shown in Figure 5.

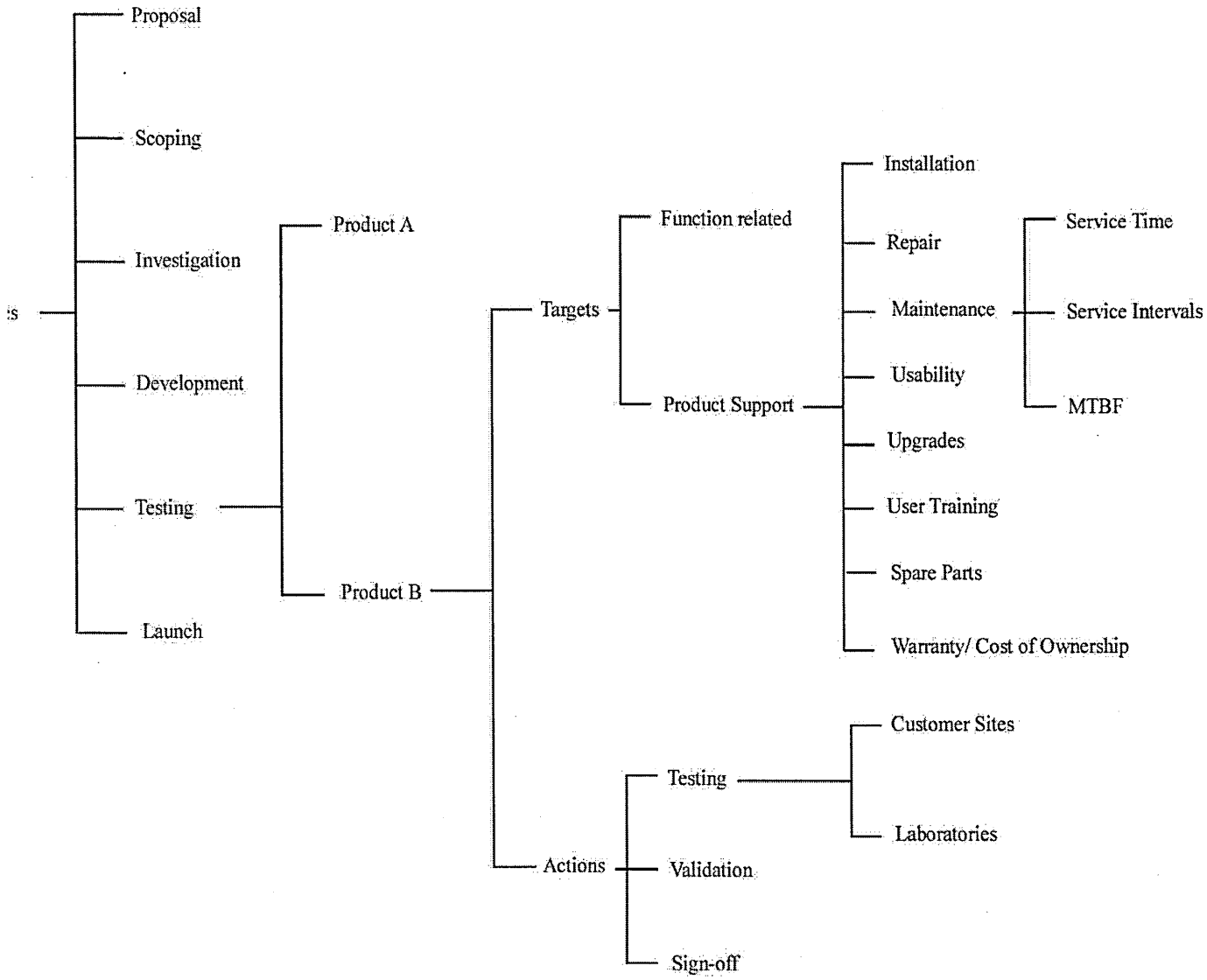

Figure 5: Systemic Network for the Testing Stage for product B

What I have developed here, working both *inductively* with the empirical and *deductively* with the theoretical field, is a fragment of a systemic network that will allow me to organize my data into purposeful categories. These categories get their meaning by existing as one possibility amongst others. One would try to have, as the most delicate options, situations which are specific enough to relate directly to individual items of data but general enough to apply to more than one. The decisions would depend on the variety offered by the data and the plausibility of the distinction mattering (Bliss *et al.*, 1979). It is important to understand that systemic networks can be quite elaborate structures with a finite number of terms and not just binary choices.

3.3.2.2. Working inductively and deductively with the network

The development of a systemic network is only a preliminary part of the data analysis process. So far, the systemic networks I have designed say only that certain choices exist. These choices represent interesting terms that might prove important and reliable as accounts of the empirical data but do not in itself say how they might appear in the data across the different cases. The next question is how now I turn what I have produced so far into something that I can use to describe most of my empirical data. To

link the network terms to descriptions of further data items I need to employ the notion of 'realization rules' (Bliss *et al.*, 1979).

The first step is to mark some more text according to the network and see if it is working. When starting doing that, one might find a number of difficulties. There might be terms, or term complexes, that are not working properly in another part of the data. For example, there might be some categories that are getting no hits. This might be in itself interesting and might need to be further investigated or it could be obvious that the terms would not get any hits because the analyst has misconstrued the situation in some way. For example, the 'validation' term in Figure 4 might not get any hits as I analyse more data because it might not be relevant in the case of another company. Another problem might be that other issues in the text that appear to be important might be left out by the network. That might say that the analysis is inadequate and we have to feed this text in the analytic dialogue we are generating. Usually this is something that can be fixed within the working network environment. Some times though it might be necessary to go back and produce a new systemic network. It is this dialogical engagement, working both inductively with the data and deductively with ad hoc categories (i.e. systemic networks), that allows the analyst to get, at some point, to the position where it would be possible to say that some firm categories have been developed which seem to be working. Only then should the researcher go back to code more data and relate it to some kind of theoretical structure.

Generating a system of coding is not straightforward. Is something a researcher has to work out laboriously. Unfortunately, "Good analysis has the irritating tendency to look as it was obvious all along" (Brown and Dowling, 1998, p.300).

3.3.3. Managing the analysis using NVivo

NVivo was used to store, organise, code, annotate, relate and recall data pertinent to the empirical exploration of the subject. Specifically, the software was used to show how many times a particular node (that is category in the language of NVivo) is used; to list all the quotes in which a specific node, or a combination of nodes, appear; to display all the segments of text that are given in a particular node and to display the nodes that correspond to a particular text. It was also used to organise the nodes into systemic networks ('trees' in the language of NVivo) to reconfigure the networks, add, change, delete, reorganise and rename the nodes as the analyses progressed. The memoing and indexing systems in NVivo proved to be sufficiently flexible to enable me keep track of my analysis as it evolved in a well-organised, systematic and effective way.

As with all technologies there is a danger in elevating specialised software like NVivo too highly. The danger is not in using such software for doing qualitative data analysis. The danger is in using them in the wrong way. Because data analysis software has trivialized coding, there is a tendency for researchers to work much more inductively. However, induction only works if the analyst also has some kind of deductive thinking. Otherwise, one may spend some time in NVivo marking the data and fixing it in categories in a way that does not say anything about the research question. After all, NVivo is only an emancipatory programme unable in itself to produce any kind of analysis. The analysis has to be done by the researcher.

Unfortunately, what young researchers tend to do is get hold of their data and try to find out what is in there by fixing it into premature nodes that they would then probably

have to unfix (Brown and Dowling, 1998). The fact is that there is nothing in the data. There is what the researcher makes of it. Analysts could treat the same data in a number of ways according to what they are researching. So, the way in which one analyzes data needs to be driven firstly by the research question one is putting to it (Brown and Dowling, 1998). Before start coding in NVivo, one must look at the data and ask what the research question is in terms of this data set and whether the network being produced is of interest in respect of what one is asking of this data. Of course, the nodes and threes may well be modified in the course of doing this, but in a meaningful and thoughtful way.

Brown and Dowling (1998) suggest that qualitative data analysis of necessity induces a janusian attitude. Janus was the two-faced Roman god who looks both ways at the portal. They explain that analysts must be prepared to look both to the theoretical and empirical fields in their research in a dialogic way. Perhaps NVivo is that electronic portal that will help us to get through with the data analysis process. But we have to look at both ways.

3.3.4. Triangulation of data

Having entered the relevant data in the Nvivo enables me to triangulate data between the interviews and the documents (see Figure 6). The following example is one of such actions to be taken in the data analysis.

3.3.4.1. Example: Design targets investigation

Previous research by Goffin (1998) showed that managers claimed that quantitative design targets were used but he found that this was not the case. Therefore particular care was taken to triangulate data to design targets. The design targets investigation, shown in Figure 6, is an effort to triangulate the design targets (regarding product support elements) with the performance data collected, the interviews and the literature. It will take place when I will investigate the product support design targets set at the specifications stage of the NPD process for the two products. This investigation will take place in two phases:

1. Starting with the product support elements found in the literature, I will use the answers of both the company's managers and the customer company recorded on the instruments $INSTR1_{MAN}1^{A/B}$ and $INSTR1_{CUST}1^{A/B}$ to identify the product support elements that are relevant to the case company.

2. From that list, I will then design a matrix that will include:
   - The post-launch performance data documented in the case company, triangulated with the managers' comments ($INSTR1_{MAN}1^{A/B}$), the product review notes ($INSTR1_{PR}$) and the customer comments ($INSTR1_{CUST}1^{A/B}$) regarding their experience of using the product, and
   - The product support design targets as found in the documents ($INSTR1_{MAN}2$) and the recommended targets suggested in the literature

This matrix will help in the triangulation of the findings for the specifications stage for both products and assess the product support input and actions for that stage.

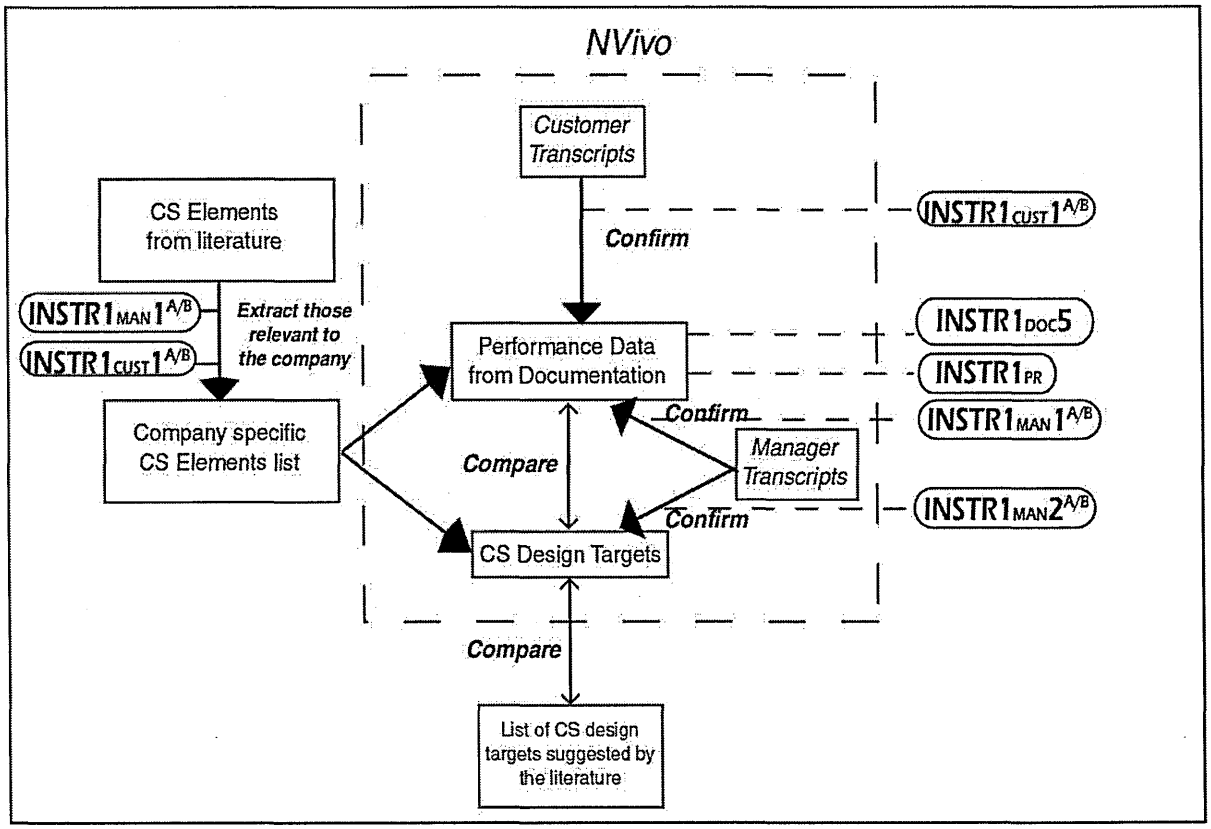

Figure 6: Product support design targets triangulation

3.4. Cross-Case Analysis

Cross-case analysis will follow the within-case analysis of the data. All case companies selected for this research will have developed a type of NPD process with stages and gates. However, various differences are expected to be found in these processes across the cases. In order to increase the validity of the comparison between the cases, a generic model of a new product development process will be employed (Ulrich and Eppinger, 2000). This generic model, with a description of the activities that take place in each stage, is illustrated in Figure 7.

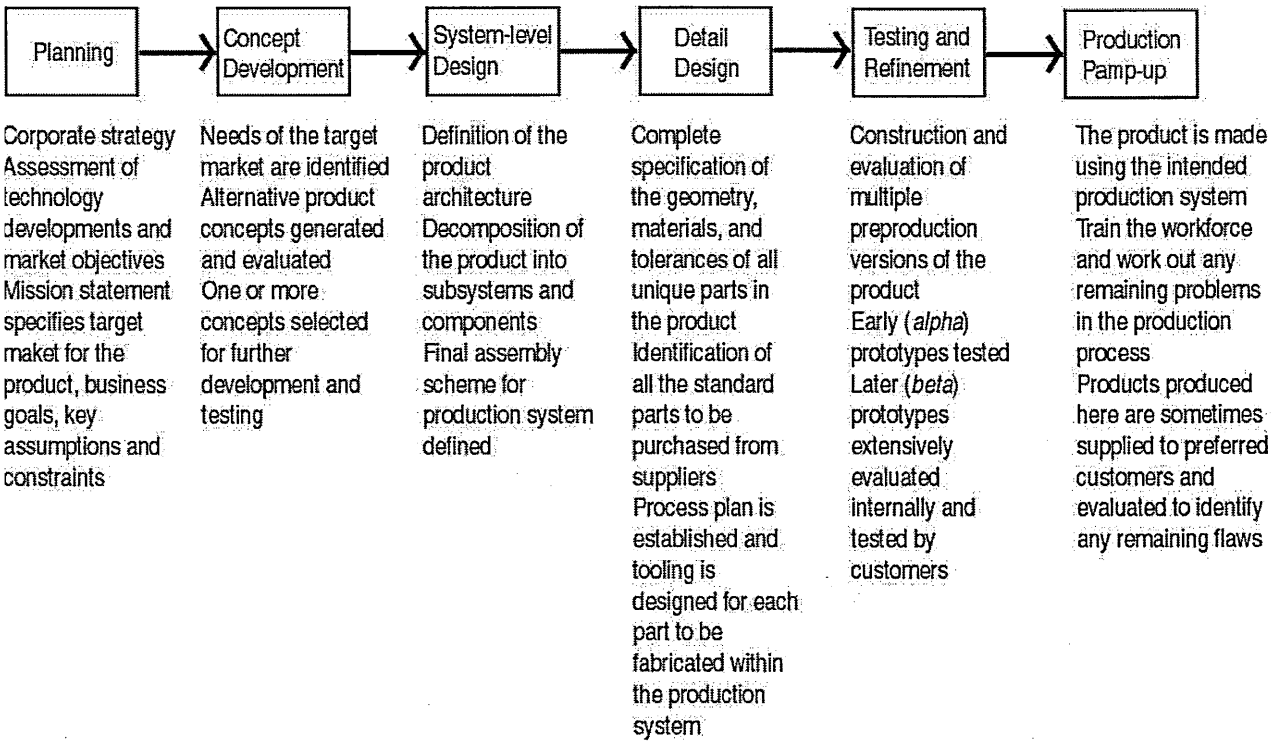

Figure 7: Generic NPD process (Ulrich and Eppinger, 2000)

The above model will be used to compare the models employed in the case companies. Based on the allocation of the stages of the NPD processes to those illustrated in the figure above, a comparison of the involvement of product support in the different NPD processes will be feasible.

3.5. Summary

The methodology selected in order to investigate the two research questions set at the beginning of this chapter is the case study research. After having organised the data collection and the analysis of the data transcripts and memos, the pilot case study was conducted. The results of this case are presented in Chapter 4.

CHAPTER 4. PILOT CASE STUDY

4.1. Introduction

In this chapter, the findings from the pilot case study will be presented. Initially, the data sources used will be given, followed by an explanation of the company organisation. The role of customer support in that organisation will be explained together with the importance given on product support. Next, the description of the new product development process and the two products' selection for this case study will lead to the details of the involvement of customer support in the NPD processes used for the development of the two products. The chapter will finish with the comparison of the approaches used for the development of the two products and the issues that still need to be addressed in the main case study.

4.2. Data Sources

The focus of the study was to investigate the involvement of product support in the NPD process of two products in the Automotive company. The methods employed for the data collection were:

- *Interviews*. The managers involved in the development of two products, one that was easier to support than the other, were selected for the interviews. The interviews contained questions regarding the involvement of product support in the NPD processes for the two products and issues they would be aware because of their positions in the company. In addition to the managers, one key customer was interviewed for product A, giving his experience with both products A and B. The managers' positions and the referencing system used are displayed in Table 4.

Product A	Reference	Product B	Reference
Car line manager in the manufacturing office	$I_{aut1ManufacturingMA}$	Supervisor for the Product B in the manufacturing business office	$I_{aut1ManufacturingMB}$
Brand manager in Europe	$I_{aut1MarketingMA}$	Brand manager in Europe	$I_{aut1MarketingMB}$
Vehicle engineer manager for Product A car line	$I_{aut1NPDMA}$	Vehicle engineer manager for the Product B car line	$I_{aut1NPDMB}$
Vehicle product strategy manager	$I_{aut1StrategyMA}$	Car product planning manager	$I_{aut1Strategy1MB}$
Operations Manager of Vehicle Service and Programs	$I_{aut1CSM}$	Project manager for Product B car line	$I_{aut1Strategy2MB}$
Upstream program manager for Product A	$I_{aut1CS1MA}$	Operations Manager of Vehicle Service and Programs	$I_{aut1CSM}$
One key customer (one Group Technical manager)	$I_{aut1CustomerMA}$	Upstream Program Manager (1)	$I_{aut1CS1MB}$
		Upstream Program Manager (2)	$I_{aut1CS2MB}$

Table 4: Positions of the respondents in Automotive company

- *Product Review Interview*. The product review was conducted with the help of an Upstream Program Manager (Table 5 for reference). This manager was fully

aware of the support performance of the two products and answered questions regarding the tasks and the relative difficulty of the tasks undertaken by the support personnel in each product.

Product Review Interview	Reference
Upstream Program Manager	$PR_{aut1CSMB}$

Table 5: Product review source in Automotive Company

- *Company Documents*. Another source of evidence was the Master Document List (see Appendix 8), an instrument used to retrieve the documents, required for the research, from the company's library and managers' files. These documents collected covered the NPD process, the product specifications, the reviews and some performance post-launch measures. The documentary sources found are presented in Table 6.

Documents	Reference
FPDS document	$D_{aut1FPDS}$
Panel 1 document	$D_{aut1P1D}$
Service Strategy Product A document	$D_{aut1SSAD}$
Service Strategy Product B document	$D_{aut1SSBD}$
Brand Positioning Product A document	$D_{aut1BPPAD}$
Feature Description Brochure Product B	$D_{aut1FDBPB}$
Mission Statement Product B	$D_{aut1MSPB}$
Program Service Strategy Product B document	$D_{aut1PSSPBD}$
Program Serviceability Design Concerns Product B document	$D_{aut1PSDCPBD}$
Serviceability Tool document	$D_{aut1STD}$

Table 6: Documentary Sources in Automotive Company

A referencing system for the above mentioned sources was devised. The system is presented in Tables 4, 5, and 6, showing both the source (i.e. interviews, product review, documents) and the reference code allocated to each particular source. For example, all references start with a letter "I" for the interviews, "PR" for the product review, "D" for the company documents, followed by the reference to the case company (i.e. "aut1" for Electronics Company) and the reference to the manager interviewed (i.e. "NPD" for the NPD manager) or to the nature of the document reviewed (i.e. "STD" for the serviceability tool document).

4.3. Company Organisation

The pilot case study was conducted in the sponsoring company, an automotive company. This company is a large multinational company, with an annual turnover that exceeds $100m a year. It operates globally, with many manufacturing plants in Europe and worldwide. The product development takes place in various places, both in Europe and the USA.

In the automotive company, the Vice President of the customer service department reports to the Vice President of Sales and Marketing. More specifically, as the operations manager of vehicle service and programs told me, "*service and sales are together, as they are the customer interface*". The Customer Service department contains the people responsible for service for each individual countries, the vehicle service and programs, which is the link towards the product development projects, the technical support to dealers, its finance and human resources, the spare parts and the repair product planning, whose work is to develop new repairing methods for the vehicles. This department deals with the customer needs in terms of support after the sale of the products (including the user-training and the documentation needs). Therefore one could argue that the terms customer service and product support for Automotive company are identical. The upper part of Automotive company's organisation, and the position of customer service in the organisation, is illustrated in Figure 8.

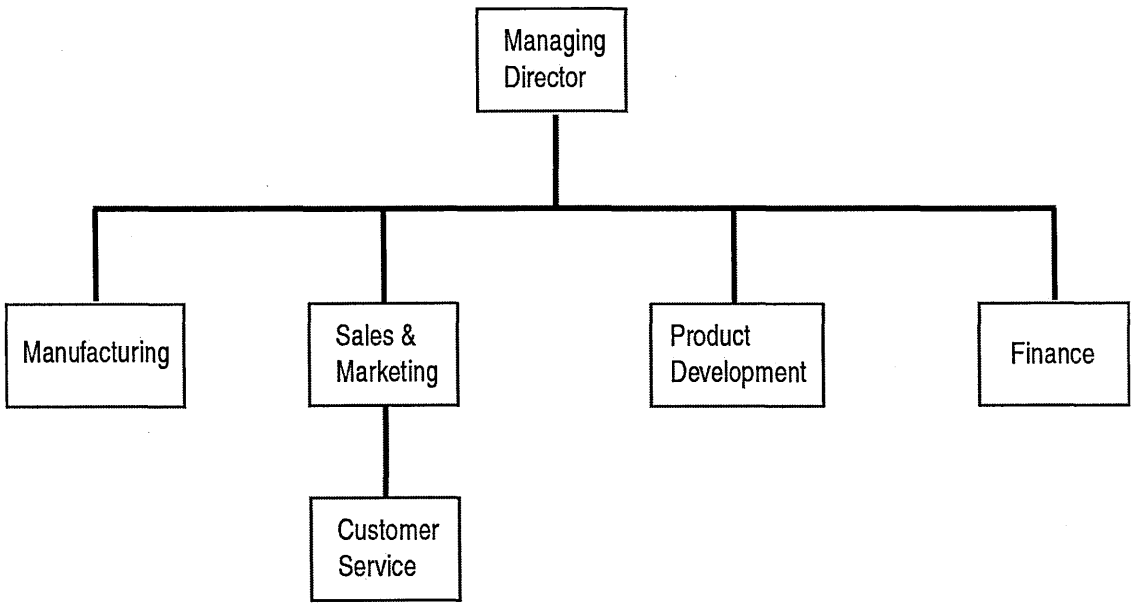

Figure 8: Position of Customer Service in Automotive company's organisation in Europe

4.3.1. The role of product support in the company

Figure 8 shows that Customer Service, which is the organisation responsible for the product support issues in the Automotive company, reports to the Sales & Marketing department of Automotive company's organisation. To understand the influence of service issues on company strategy, 3 managers were asked whether product support leads the product development in their company. Their answers showed that the position of product support in the organisation has limited effect when making decisions about new products. "*You move into service, or after sales, there is less focus as a company. I don't say if this is right or wrong, I just say how it is perceived... no we are not set up or structured or our culture is not set up to support that sort of approach in terms of using the service as a differentiator*" ($I_{aut1MarketingMA}$), "*the answer is no, it certainly isn't. The driving area within Automotive company at the moment is something else*" ($I_{aut1NPDMA}$). Within the customer service department the view is also in these lines: "*it was never seeing as "leading", high-tech, go-get-it part of the organisation. It was a bit of a backwater*" ($I_{aut1CSM}$).

There was a disagreement on those views by the vehicle product strategy manager, who believes that the position of customer service in Automotive company's organisation is changing: "*historically we haven't put as much emphasis on the service side of the business as we have needed to. That is changed and, I still wouldn't call it the leading part of the business, but there is much greater emphasis on the service experience as well*". However, the location of Customer Service below the Sales & Marketing umbrella shows that there is some way before product support becomes a leading part in Automotive company's organisation.

One would expect that the higher the emphasis on the product support from the organisation, the higher the involvement of the product support in the development of new products. With the above views as a starting point, it will be interesting to see how the customer service requirements have been incorporated in the design of new Automotive company vehicles. To begin with, it will be useful to see the importance of product support and its elements to the customers of the Automotive Company.

4.3.2. Importance of Product Support Elements

Managers from the different departments that participated in the development of the products were asked to assess the importance of service and support issues to the customers using both Products A and B. In addition to those, one key customer (user of Product A) was also asked about this issue. All the relevant answers are presented in Table 7.

Although the nature of the two products is different, all managers agreed on the importance of the service and support provision to the customers. According to some of the managers, service has become more and more important, even has become "*a key*" ($I_{aut1ManufacturingMA}$) for the customers of Product A. As the brand manager quoted more specifically: "*The after-sales experience, what you can offer, will become much more of the differentiation between different manufacturers... the weight of the customer service and what happens in the process of getting the vehicle or actually owning the vehicle becomes more and more important... more so, as we've gone on through time*".

The interviews with the customer also revealed the importance of product support provision to the customers of the Automotive Company. He said that product support is "*Extremely important. Costs as in...(the service costs)... extremely important because when you've got, how many Product As we've got, 15000, something in that order, a small variation makes a big impact...we have just recently refused a product because of the service, poor service, after sales service... product support is a quite major element of why we choose a product*" ($I_{aut1CustomerMA}$).

For Product B, the managers involved in its development similarly thought that "service is extremely important because Product B type of cars are obviously at the lower end of the market in terms of cost, and one of the things in particular our customers are looking for is value for money" ($I_{aut1NPDMB}$). The manufacturing manager added: "*serviceability is a key issue for them [our customers]*". One of the most important comments, though, came from the brand manager. He said: "*In these days, products become more and more reliable, very similar performance, fuel economy and so forth. [Product support issues are] potentially key differentiators between companies*". No customers were interviewed for this product, as the product was just launched in the

market, and therefore there are no comments from the customers about the importance of product support to them.

However, there was a difference in the importance customers who are buying the Product B place to the service provision. According to the claims of the project manager for the Product B car line, service costs and provision is less important than the initial purchase costs: "*I believe that service costs are less relevant to the purchase cost for our* [target] *customer*". He thinks that the influence of the service issues in the buying behaviour of this product's customers is quite weak. At this point, the brand manager adds: "*It is not the primary determining factor unless you have a very negative experience from a car manufacturer in the past*". More details of the importance of each of the product support elements for each of the products are presented in the following page (Table 7).

Elements of Product support*	Applicable	Quotes for Product A: Professional vehicle	Quotes for Product B: Retail car
Installation	-	-	-
Training[1]	**Yes**	"*I am not sure customers are looking for a lot of training*" ($I_{aut1ManufacturingMA}$)	"*The customer doesn't think it is important because they think they know how they can do it all*" ($I_{aut1Strategy2MB}$)
Usability	**Yes**	"*That's pretty important*" ($I_{aut1ManufacturingMA}$)	"*I think it is probably quite important*" ($I_{aut1Strategy2MB}$)
Reliability	**Yes**	"*It can guarantee that it will start in the morning and run till you need it*" ($I_{aut1ManufacturingMA}$) "*If the vehicle is not running they* [customers] *are not working, so they are not earning money*" ($I_{aut1NPDMA}$)	"*I think it is important but I also think there are assumptions that every produ is reliable... I think there is a progressive creep of customer expectation on reliability*" ($I_{aut1Strategy2MB}$)r)
Serviceability	**Yes**	"*Reducing the downtime of the vehicle is absolutely vital*" ($I_{aut1NPDMA}$) "*When it does need service or some work done, that is invisible to them, it doesn't interrupt their business at all*" ($I_{aut1ManufacturingMA}$) "*A vehicle out for service is a big expense to us*" ($I_{aut1CustomerMA}$)	"*I think serviceability is a key issue for them*" ($I_{aut1ManufacturingMB}$) "*Service price is an important aspect*" ($I_{aut1Strategy2MB}$)
Field Organisation	**Yes**	"*When things happen and things do happen, they need to have the support*" ($I_{aut1StrategyMA}$) "*Convenience through dealerships*" ($I_{aut1MarketingMA}$) "*Speed of response*" ($I_{aut1NPDMA}$) "*We have just recently refused a product because of the service, poor service, after sales service*" ($I_{aut1CustomerMA}$)	"*It's about a company that's been, you can rely on it will give you a good customer service, when things do go wrong*" ($I_{aut1MarketingMB}$)
Spare Parts	**Yes**	"*That's pretty important as well*" ($I_{aut1ManufacturingMA}$) "*It is not that important until he needs them. Then they become really important*" ($I_{aut1MarketingMA}$)	"*Never ever reads it*" ($I_{aut1NPDMB}$) "*I think in reality their need is far lees than they imagine... but they rate it quit highly... in cost of ownership in fact it is a very small factor*" ($I_{aut1Strategy2MB}$)
Documentation	**Yes**	"*I am sure they want the documentation, they like the safety feeling even if they don't use it*" ($I_{aut1ManufacturingMA}$) "*If you are in Germany that's very high*" ($I_{aut1MarketingMA}$)	-
Maintenance/ Preventative Maintenance	**Yes**	"*Reduce downtime*" ($I_{aut1NPDMA}$)	"*I think they think less about those things*" ($I_{aut1Strategy2MB}$)
Repair	**Yes**	"*Minimise the amount of unplanned service or breakdown repair that the product might need*" ($I_{aut1ManufacturingMA}$)	"*I don't think they care too much about it*" ($I_{aut1Strategy2MB}$)
Upgrades	**Yes**	-	-
Online Support	**No**	-	-
Cost of Ownership	**Yes**	"*Commercial vehicle is a hard environment and operating costs are key in the purchase decision process*" ($I_{aut1NPDMA}$) "*Cost of ownership is so important for our target customer*" ($I_{aut1StrategyMA}$) "*We look at the whole life costs before we decide... Whole life costs are extremely important*" ($I_{aut1CustomerMA}$)	"*As long as we are there with the pack, it's not a major differentiator to have lower cost of ownership, it is not the prime reason for buying a vehicle*" ($I_{aut1CS1MB}$) "*Cost of ownership is not a primary attribute that we are looking to excel upon it*" ($I_{aut1MarketingMB}$)

*Based on Goffin (1998)

Table 7: Product support elements and their importance for Automotive company customers

[1] The Automotive Company provides Training to the dealers and not to the customers. The user training is carried out by the dealers when they hand over the vehicle to the customers

Although the researcher used similar probes and questions to the interviews with managers of both products, those probes and questions generated far more comments for the Product A than the Product B. There are comments for the elements of Reliability, Maintenance and Repair for the Product A, showing the importance of those elements to the customers, according to the managers' opinions. In contrast, there was no recording of such comments from the managers interviewed about Product B, something that could be attributed to the lower importance of those elements to the users of Product B than those of the Product A. This difference could be mainly based on the nature of the two products, as the Product A is addressed directly to businesses, where many product support elements play an influential role in the decision-making process, and Product B is mainly addressed to retail customers, for whom the majority of the product support elements might be not important.

4.4. Company NPD Process

The product development process used in the Automotive Company is illustrated in Figure 9.

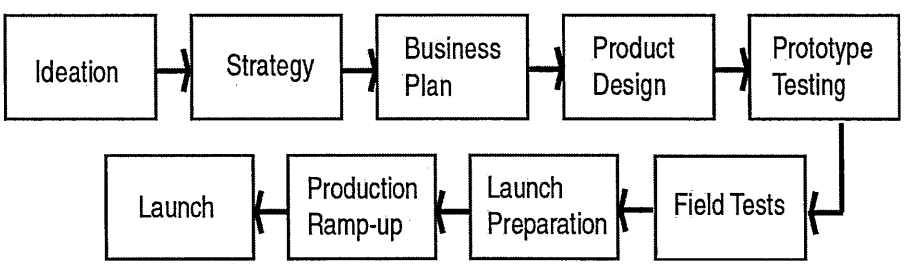

Figure 9: Product development process in Automotive Company ($D_{autIFPDSD}$)

This figure shows that the product development process comprises 9 different stages (a stage-gate process). The beginning of the project starts with the idea for a new product (Ideation). A link with the current and the future strategy of the company is created based on the customer and market requirements and the competitive market environment, which are developed in the Strategy stage. This is the stage where the strategy for reliability, quality and product support is developed. After that stage, the product enters the Business Plan phase, where the specifications are set and the sources for parts and materials are explored. At this stage, the targets for service elements are set, both of qualitative and quantitative nature. Next, we have the Product Design and development, which includes all actions for designing the product as well as tooling for manufacturing. Then the product enters the Prototype Testing and Field Tests stages, during which prototypes are tested in laboratories and in the field in order to identify possible problems. After the road tests are completed, and the final product design is signed-off by the development team, the product enters the Launch Preparation and then the Production stages, where it gets produced in the various manufacturing sites before it gets launched in the marketplace. At the end of each of the stages in Figure 9, there are gates, which are used as decision points for the continuity of the project.

The development process for new products "*is usually about 3 to 4 years, depends on the complexity of the program*" ($I_{autINPDMA}$). The product development project for Product A started in 1996 and the final product was launched in the market in 2000. Development projects for products like the Product B take about the same time as the Product A. The development project for Product B started in 1998 and the final product was launched in the UK market in 2002.

The departments that were represented in both NPD teams were:

- Engineering
- Manufacturing
- Marketing
- Sales and service

For the Product A, a matrix-type organisation was employed. As the vehicle engineer manager said: "*The main, if you go through the percentage of people, the main contributing area is engineering, but you obviously have support from manufacturing, you obviously have support from marketing, in terms of setting up the marketing assumptions and the product definitions and the customer definitions, you have support from the sales and service division, so the customer service provides support at all the stages of that program development...there is person or a couple of people assigned to the program, and they track the program right the way through*".

At the Product B, on the other hand, the type of organisation employed changed during the course of the project: "*It was started off very much as a project organisation. So all of the people were very much dedicated to the project, although they did have ties back to functional organisation. So it was very much project-oriented to begin with. However, towards the end of the program that changed. And the emphasis went more towards the functional organisation than the project organisation. That's how the organisation is now, it is more function biased*" ($I_{aut1NPDMB}$).

They used two main measures for both products to assess the project performance: "*the financial returns and the attribute performance, so how the vehicle performs in the marketplace, the quality of the vehicles that are going to the customers now, the amount of last minute changes, the amount of potential recalls that we might have had, things like those*" ($I_{aut1NPDMB}$). Another measure that was used only for Product B was the time-to-market: "*Time was another thing that was very heavily looked at*" ($I_{aut1NPDMB}$). They used no product support measures for the project performance. In the following paragraphs, the process of selecting the two products will be described.

4.5. Choosing The Two Products

Initially, the pilot case started with the investigation of product A, which was a B2B product. However, only this one product was found with the industrial product characteristics inside Automotive Company. The main reason for that is that most of Automotive Company's products are retail vehicles, targeted at consumers rather than companies. Although after-sales can be very important, it should be noted that is not equally important for all types of products. The nature of product B, a consumer product rather than a capital goods product, poses a threat to the internal validity of this study, as the two products are not easily comparable. Some companies, however, do have fleets of some of those vehicles (for example, the car rental companies), and therefore these companies could be treated as business customers. Interviews were conducted with the service managers in the UK premises in order to identify two products, one that it is easy to support and one that it is difficult to support, that have been developed completely in Europe during the last 5 years.

The two products selected were:

i. A professional vehicle (Product A)

ii. A retail car (Product B)

4.5.1. Product selection

4.5.1.1. Product review interview

The main reasons for selecting these two products are based on their performance in the marketplace in terms of product support. From these two products, the Product A (professional vehicle) was perceived by three service managers as more difficult to support than the Product B (retail car).

4.5.1.2. Documentary evidence

The views of the three service managers were supported by the performance data (collected from the company's documents) on product support for the two products. Table 8 includes some product support elements and the performance of the vehicles on those elements. On the left hand side of the table, elements of product support that are measured in Automotive Company are presented. These elements are: Things gone wrong (which is a measure of the reliability of the products), repairs, satisfaction with vehicle quality, customer satisfaction with service quality, cost of service, cost of repair and cost of ownership. Then, the product support personnel in Automotive Company measured the performance of the two products along these elements and the results are presented in the two columns of the table.

Element	Product A: Professional vehicle	Product B: Retail Car
Things Gone Wrong per thousand vehicles	1882	2281
Repairs per thousand vehicles	276	278
Satisfaction with Vehicle Quality (% very of completely satisfied)	40	57
Customer Satisfaction with Service (% very or completely satisfied)	48	51
Cost of Service (per 60000miles/ 3years)	168*	100*
Cost of Repair (per 60000miles/ 3years)	139*	100*
Cost of Ownership (per 60000miles/ 3years, fuel costs not included)	131*	100*
*=Index numbers[2]		

Table 8: Performance data of Products A and B (Source: ($D_{autIPID}$) and Customer Service Department)

[2] The actual data collected from Automotive Company is confidential. Index numbers is a valid way to present this data. Example of the numbers presented here: Product B has 68% better Cost of Service over Product A.

The majority of the data on Table 8 support the view that product A is relatively difficult to support, as the costs of service, repair and ownership were much higher on Product A than on Product B. In addition, the customer satisfaction with both the vehicle quality and the service was higher on Product B. One of the main reasons is that the customers of the professional vehicle made complaints about the reliability of one of its parts when used in roads with high grade. On the other hand, the service requirements for the retail car were more elastic (for example, one of the targets was to achieve a competitive cost of ownership and not be "best in the class"). This elasticity of requirements could also explain the performance of Product B on the measure "things gone wrong" was not as good as in Product A.

4.5.2. Launch dates

The Product A is a professional vehicle, launched in the 2000. It is a completely new vehicle, replacing its predecessor in a highly competitive market environment. It has a vast number of derivatives, as the company tried to address many individual niches using the same platform. On the other hand, the Product B is a retail car, launched into the market in the 2002 as a replacement of its predecessor in the private small car market environment. Product B was also a completely new vehicle, based on a totally new platform. The market environment when this product was launched was highly competitive, with many rival companies trying to increase their market shares.

In the following paragraphs I am going to show the importance of the product support to the users of both products, the involvement of product support in the product development and the decisions made at that time.

4.6 NPD Process Stages For A And B

4.6.1. Ideation and Strategy

During these first two stages of product development, the idea for the product is created and then the strategies for the brand, the markets, the competitors and the service are developed.

In the very first steps of the product development process of both products A and B, the Ideation point, the product support department does not have any influence: "*I don't think we have yearly meetings with the service managers on product planning for the future*" ($I_{aut1Strategy1MB}$). At this first stage of product development, the product support involvement "*did not start immediately with the initial concepts, but was considered very early on*" ($I_{aut1Strategy1MB}$). Another manager commented that "*If you go back into the original strategy, just before the program started* [the Ideation stage], *no, the* [product support] *would not have been a part of that development group at that time. As the program started, however, when you set-up a team structure, that structure includes* [product support] ($I_{aut1Strategy2MB}$).

So the product support department was not represented in the Ideation stage, but had a representative "*right at the very early stages of the strategy*" ($I_{aut1NPDMA}$) for both products. This manager, an upstream program manager, "*worked with the teams from the concept development all the way through to the launch*" ($I_{aut1CSM}$). In Table 9 are presented the responsibilities and the actions of the product support representative at these two first stages of both products' product development process, and in Table 10 all the document quotes found at this stage of the product development projects.

Product support representative	Product A: Professional vehicle	Product B: Retail car
Responsibilities	1. "*Help setting up the strategy in terms of the cost of ownership*" ($I_{aut1NPDMA}$), by "*participating in the review of the company's position in the marketplace*" ($I_{aut1MarketingMA}$) 2. "*Help make sure that decisions are influenced and that we can service it*" ($I_{aut1CSM}$)	1. "*The* [product support] *role right from the very beginning was to represent the function and the importance, by the way not only of service but also of accessories sales and that sort of things*" ($I_{aut1Strategy2MB}$) 2. "*Pull the service into those discussions, especially if there were trade-offs between serviceability and production capability, or cost of materials or performance or whatever aspect*" ($I_{aut1Strategy2MB}$)
Actions	1. Field experience: "*Feed in top ten customer problems*" ($I_{aut1CSM}$) 2. Set targets: "*Set targets for the cost of ownership*" ($I_{aut1NPDMA}$), which was one of the main target attributes for the new product (see Table 10 for the targets)	1. Field experience: "*Give the field experience with the previous models and things that had to be fixed*" ($I_{aut1CS1MB}$), "*provided lessons learned from the existing products in the field*" ($I_{aut1CSM}$) 2. "*Measure competitor performance in the after-sales service*" ($I_{aut1CSM}$) 3. "*Set-up the service strategy*" ($I_{aut1CSM}$)
Input to documents	Brand Positioning document[3] (see Table 10 for document quotes)	Service Strategy document[4] (see Table 10 for document quotes)

Table 9: Input of the product support at the Ideation and Strategy stages

[3] This document is a marketing document that shows the targets customers, their needs and the competitor analysis along key marketing issues

[4] This document includes the strategy for the diagnostics and the service parts, the level of service, the tooling and recycling and also the strategy for the publications and the dealer training in order to achieve the service times required

Elements of Product support*	Applicable	'Brand Positioning' document quotes for Product A: Professional vehicle	1.'Feature Description Brochure' 2. 'Mission Statement' and 3. 'Program Service Strategy' document quotes for Product B: Retail car
Installation	-	-	-
Training	**Yes**	-	-
Usability	**Yes**	"Comfortable and handy… driving experience should be high"	1. "Increased comfort, interior space, ergonomics, manoeuvrability"
Reliability	**Yes**	"Strong, durable, with minimum downtime…need for a reliable vehicle"	
Serviceability	**Yes**	"Vehicle to perform everyday with a minimum downtime… fix it right the first time"	2. "Minimise complexity" 3. "Improve serviceability" – "Current and past top service concerns list"
Field Organisation	**Yes**	"Business relationship with customers"	-
Spare Parts	**Yes**	-	3. "Carry-over parts should be used wherever possible"
Documentation	**Yes**	-	-
Maintenance/ Preventative Maintenance	**Yes**	"Extended service intervals"	1. "Routine maintenance requirements will be minimal" 3. "Longer service intervals to meet competition" – 20000 kilometres – Cost of Service target – Competitive analysis
Repair	**Yes**	"Low cost accident repair"	1. "Lower cost of repairs" 3. "Lower repair cost" – Cost of Repair target – Competitive analysis
Upgrades	**Yes**	-	-
Online Support	-	-	-
Cost of Ownership	**Yes**	"Target customer wants low cost of ownership… essential driver of purchase decision and satisfaction"	3. "Cost of ownership has to be among the leaders" 3. "Best fuel economy"

Note: Blank cells show that no document quotes existed for those elements of product support

Table 10: Document quotes about the Product support input during the Ideation and Strategy Stage

*Based on Goffin (1998)

The Brand Positioning document for the Product A showed that Automotive company actually wanted to achieve the best cost-of-ownership performance in the market, as was stated in the document: "*the maximum return on investment is critically important to every core target customer*" ($D_{aut1BPPAD}$) and it is in line with the second action shown in Table 9. Other targets set at this stage were: "*the reliability of the product, what is the vehicle like to drive, what is the steering like, what is the ride like, what's the handling like and so on*" ($I_{aut1NPDMA}$), and these targets were based the field experience with current products.

Managers' quotes about the Product B were also in line with the document quotes collected at this stage. The service strategy document, which is basically the service strategy for the product development project for Product B, had a list of current and past top concerns with the products in the field (in line with the first action presented in Table 9) and measurement of competitors' performance on the costs of maintenance and repair (in agreement with the second action presented in Table 9).

From Table 10, one can see that no numerical targets have been made for Product A, whereas two key quantitative goals were set for Product B. The reason behind this is that quantitative targets for the various product support elements actually are set at the next stage of the product development process, the Business Plan stage. However, for the development of Product B, the product support held a more proactive stance and included these two targets early at this strategic stage of the NPD process.

At the Strategy stage of the product development project, the product support representative, as a member of the product development team for the Product A, tried to influence the decision makers, however not all of the requirements were addressed. There were limits to what could be achieved with the new product, mainly of financial nature: "*a list of requirements. They affectively get cost and those that are affordable make the program and those that aren't...I think the visibility of service within the product development phase is somewhat limited. I think service doesn't always get the priority that maybe it should have... service is somewhere off ranked third or fourth behind other key indicators of importance. I mean, part of that is right because the first one is legal requirements, we have to do something to maintain and stay in business and that's priority one, but there are some requirements, making improvements to serviceability and they are on the bottom of the list, maybe they shouldn't be*" ($I_{aut1ManufacturingMA}$).

As with Product A, for Product B the product support representative tried to influence the decisions. However, the product support requirements were given a certain priority based on an agreement early on the product development process: "*There was an agreement as to the priority to be put on the service requirements. By that, I mean when we first kicked-off the program, there was a high level agreement that whether each attribute for the vehicle should be competitive, best in class or leadership*" ($I_{aut1NPDMB}$).

When asked about the influence of the product support in this early stage of the development of the Product A, the Vehicle engineer manager regarded the product support as one of the decision makers. However, the product support manager did not agree, feeling that there was some influence on the decision-making for the product. She commented on her role: "*help make sure that decisions are influenced*" ($I_{aut1CSM}$). The same view applies and to the Product B, as, although "*Customer service division were part of all those product decisions. They set engineering targets, customer service*

division set engineering targets, as we said about operating cost" ($I_{aut1Strategy1MB}$), the Product support managers think that they provided information to the decision-makers, as: "*We don't have a massive influence in the concept of things*" ($I_{aut1CS2MB}$).

From the above, one could observe a higher involvement of the product support in the product development project of Product B during the Ideation and Strategy stages. This is based mainly in the creation of a concrete service strategy, with early, competition-based broad goals presented to the product development team. It showed that the development team took into consideration elements of product support like the spare parts, the diagnostics and the service early in the process.

4.6.2. Business Plan

At this stage, there was still one person responsible, an upstream program manager, for all the service aspects of both products. This product support representative, who reported to the operations manager of the vehicle service and programs, had to communicate to the development team the requirements of the support department, the design goals from the service department and to evaluate the product at the preliminary design stage based on those requirements: "*So we are going and tell them what our requirements are, what can and can't be done in a service environment*" ($I_{aut1CSM}$), "*We were there to give advice, we were consultants, perhaps helped them understand how to meet the objectives*" ($I_{aut1CS1MA}$). As the vehicle engineer manager said: "*give the targets and then to monitor the product as it is developed*". Both agreed that the product support manager helped the designers when faced with difficulties in meeting the requirements.

The product support targets for the two products are now quantified and presented in Table 11. In this table, on the left side the targets are presented and on the right side the actual performance of the product support elements in the field. All the design targets were about the costs, with the exception of the maintenance interval. As shown in the table, some of those targets were actually met (maintenance intervals and Cost of ownership for Product B), where some others were slightly missed (not enough though to concern the product development teams).

Product A: Professional vehicle		
Element	**Target**	**Actual Version**
Maintenance Intervals (kilometres)	30000km	30000km
Cost of Ownership (per 60000miles/ 3 years)	100*	101*
Product B: Retail car		
Element	**Target**	**Actual Version**
Cost of Service (per 60000miles/ 3 years)	100*	103*
Maintenance Intervals (kilometres)	20000km	20000km
Cost of Repair (per 60000miles/ 3 years)	100*	101*
Cost of Ownership (per 60000miles/ 3 years)	100*	99*

*=Index numbers (actual figures confidential)

Table 11: Design targets and actual performance of Products A and B (Source: Customer Service Department)

Comparing Table 11 with Table 10, one could argue that the overall targets set at the Strategy stage for Product A were not all transformed into design goals. Only the Cost of ownership element has been transformed into a design goal, together with the service interval. This comes to an agreement with the managers' comments that the cost of ownership was set as a target for Product A. However, not all the strategy targets were quantified and transformed into design goals at this stage. Examples of such targets are the repair, the usability, the reliability and the serviceability targets.

On the other hand, Product B had more design goals on product support elements than Product A. Such goals were the cost of service and the cost of repair. However, there were strategy targets that were not transformed into design goals, such as the usability, the upgrades and the spare parts elements.

The role of the upstream program manager was in the case of both products more focused on monitoring the product development. And, although the responsibility for the service aspects of the product was on his shoulders, he "*had only limited effect on what could be achieved*" ($I_{aut1ManufacturingMA}$). Not all requirements had been met, as "*there were sometimes some cases where that wasn't feasible*" ($I_{aut1NPDMB}$). His decisions were based on "*... priorities. He is not so concerned about some aspects of the vehicle and very concerned about others*" ($I_{aut1ManufacuringMA}$).

4.6.3. Product Design

During this stage, the detailed designs are developed. For the development of the vehicle, the company used extensively a version of the Quality Function Deployment (QFD) in order to transform the customer requirements into functional properties of the vehicle. The product support managers of both products brought their teams into the development team in order to work with the engineers and the designers.

The responsibilities of the product support teams, for both products A and B, were (see Table 12):

a. Provide input into the engineering and work with engineers and designers in order to help meet the support requirements. Weekly meetings were held with dozens of engineers and managers from marketing, product support and manufacturing departments, in an effort to study the CAD drawings and to raise ideas and concerns about the designs. Product support's role was to elaborate the service targets and help engineers meet those targets.
b. Monitor the designs as they were developed. Regular contacts between the upstream managers and the engineering teams were made, and the designs were frequently subjected to product support scrutiny.
c. Evaluate the product in order to see whether it finally met the product support criteria with the help of service engineers and several tools that were available.

After the initial designs were developed, the representative of product support audited the designs to see whether they met the service requirements: "*they evaluated those component designs, those system designs to understand whether they met their requirements. And if they didn't, they worked with the team to help us understand what it needed to be done in order to make the parts or the systems work the way they needed to... we had a weekly, what we call a compatibility, review, where everybody sits around, and we went through in a room a particular area of the vehicle on the CAD station. And just looked through each area of the vehicle ... and customer service people were there, and so they tried to, we tried to make assessments in the virtual as to how easy it was to service the vehicle*" ($I_{aut1NPDMA}$). This audit took place in the development of both products.

Responsibilities	**Product A: Professional vehicle**	**Product B: Retail car**
Provide input into the engineering	Input "*as which parts should be serviceable, what the target labour times should be so as they are doing their designs they take into account how it can be serviced as well*" ($I_{aut1CSM}$), in the form of design suggestions	"*They worked with the team to help us understand what it needed to be done in order to make the parts or the systems work the way they needed to... we tried to make assessments in the virtual as to how easy it was to service the vehicle*" ($I_{aut1NPDMB}$) "*We are there to give advice, we are consultants*" ($I_{aut1CS1MB}$). One key document developed for this input was the 'program serviceability design concerns document'[5]
Monitor the designs	The product support team would "*look at the package box with them, to see whether things are accessible, we would take parts out, we would look at engineering drawings*" ($I_{aut1CSM}$), "*look at access to various key components that they know they are going have to service on a regular basis. And they will try to estimate the time to change, based on those designs*" ($I_{aut1NPDMA}$)	"*We have to monitor, we have seven particular areas that are identified as key musts. And we have to try and close all those out, make sure that all those requirements are met*" ($I_{aut1CS2MB}$)
Evaluate the product	The vehicle engineer manager said: [product support] are "*responsible for evaluating the product at the design stage*"	"*They evaluated those component designs, those system designs to understand whether they met their requirements*" ($I_{aut1NPDMB}$). This evaluation was made through the 'serviceability tool' document[6].

Table 12: Responsibilities of product support during the Design stage

From Table 12, one can identify two major differences between the two products at this stage are:

- The existence of a document called "program serviceability design concerns document", which was produced half way through the development of the

[5] In the program serviceability design concerns document, the company's support managers presented their aims to reduce the service needs and the repair costs of the vehicle, thereby producing a lower cost of ownership. The document also illustrated several design concepts and their impact on the service requirements as they were implemented on Product B.

[6] The serviceability tool was a tool that included 1250 items to be checked when auditing the design of the products. This tool included items for the scheduled maintenance, the repair, and the serviceability of the Product B, together with some checks for the usability of the vehicle.

Product B, and was used for providing product support input into the engineering and

- The serviceability tool, which was used for the evaluation of the service of the Product B at the design stage.

Both product support teams had the same responsibilities and most of their actions were similar, as they both had the chance to evaluate the designs against the service requirements. The two differences presented above, the program serviceability design concerns document and the serviceability tool, increased the amount of input the product support provided at the design stage of the Product B, comparing to the input on the Product A, as the evaluation was better documented and performed.

4.6.4. Prototype Testing and Field Testing

After the Product design stage, the product enters the Prototype Testing and Field Tests stages, during which prototypes are tested in laboratories and in the field in order to identify possible problems. When the physical products were first produced as prototypes, the product support department was represented by a representative in the NPD team, supported by a team of managers. Their responsibilities were the following:

a. Evaluate the service of the product
b. Sign-off the final product designs
c. Create the product support plans for the launch

To achieve that, the team took several actions during the development of both products A and B. These actions were:

- Review prototypes: "*a review of the first prototypes to look for service problems and, based on that, they'd feedback any concerns they have back into the program and push for changes*" ($I_{aut1ManufacturingMA}$)
- Conduct exercises in workshops: "*They would take the prototype to their workshops and they would actually conduct a number of exercises to replace some components, to replace the clutch for example, replace the break line etc*" ($I_{aut1NPDMA}$)
- Field Tests: "*There is field evaluation... And we monitor the product against our requirements*" ($I_{aut1CS2MB}$)

One difference between the two products has been identified at this stage. The assessment of the performance of the Product B at this stage was based on the serviceability tool document described at the product design stage. This tool included targets against which the product should be tested, making those targets much better documented and much clearer to the service personnel. During the interviews, it also occurred that this careful approach led to changes over the final design of the Product B. The design of a part in the front end of the car changed, improving the access to the engine, and thus reducing the time it took to service it.

After the completion of those reviews and exercises, and after the required changes had been made, the product support representative had to "*sign off the service aspects of the product*" ($I_{aut1CS2MB}$). The product support sign-off "*was part of the engineering sign-off*" ($I_{aut1NPDMA}$).

At this stage, an after-sales product support plan for both products was developed in order to prepare the dealers for the service of the new products, to provide them with

the required service equipment and the spare parts necessary for their operations. This plan also included the preparation of the relevant product documentation and was developed solely from the product support department in the company. At the end of this phase, the product was ready to move to the final stages, the Launch Preparation, Production and Launch.

4.6.5. Launch Preparation, Production and Launch

After the sign-off of the final product design (part of which was the product support sign-off), the product enters the last three stages of its development, the Launch Preparation, Production and the Launch in the marketplace. During these stages, the final designs are transformed into the physical products in high volume production lines and then launched in the markets. At this phase, "*when you get passed the prototype, in theory, you've got a change cut off and only job stopping changes are allowed after that point. It is unlikely that we do changes for service at that point, because it is too disruptive to the launch process*" ($I_{aut1ManufacturingMA}$).

For both products A and B, the product support had the responsibility to set-up and prepare the after sales organisation, in order to be ready for launch: *the emphasis moves away from the design of the vehicle to getting the service organisation backup in place, ready for the launch. Are all the spares in place, the special tools, the manuals and all those good things?*" ($I_{aut1ManufacturingMA}$)

In addition to those actions, and due to the importance of the cost of ownership as a marketing element for the Product A, product support provided the marketing department with all the required information: "*We used maintenance and technical help as marketing elements, but not as the main marketing message. They are used as part of the overall package... We used some of the elements that are considered, service elements, for the promotion of the product... the main marketing messages included cost of ownership etc. And those were the messages we used as the main messages, when we get the dealers trained, the others to understand what the product was and also some of the advertising*" ($I_{aut1MarketingMA}$). However, product support had no influence over any of the product's promotion and marketing elements: "*We don't influence the marketing of the new products, no. We provide information, but we wouldn't influence what are the most important things in marketing the Product A*" ($I_{aut1CSM}$).

4.7. Summary Of Findings

In this section, a comparison of the involvement of the product support in the New Product Development process of the two products will be presented.

The key findings from the development of products A and B and the product support involvement in those projects are illustrated in Table 13. This table is based not only on managers' quotes, but also on the quotes found in documents related to the NPD processes used. The table shows all the stages followed in the development of both products separately, together with a timescale, in order to place actions into time periods. For each stage, the actions taken by product support are shown, together with the targets set by product support (whenever that happened).

Product A

NPD Stages	Ideation	Strategy	Business Plan	Product Design	Prototype Testing	Field Tests	Launch Preparation	Production Ramp-up	Launch
Timescale	1996	End 1996	End 1997	Start 1997	Start 1998	End 1998	Start 1999	End 1999	Mid 2000
Product Support Actions	No involvement	Product and Service Information	Set Service Targets	1. Design Suggestions 2. Monitor the product development	Conduct reviews	1. Conduct reviews 2. Sign-off the final designs	Prepare the after-sales organisation and the spare parts		
Product Support Targets			Reliability Maintenance Cost-of-ownership	No design targets					

Product B

NPD Stages	Ideation	Strategy	Business Plan	Product Design	Prototype Testing	Field Tests	Launch Preparation	Production Ramp-up	Launch
Timescale	1998	End 1998	Mid 1999	End 1999	Mid 2000	End 2000	Start 2001	End 2001	Mid 2002
Product Support Actions	No involvement	1. Product and Service Information 2. Create Service Strategy	Set Service Targets	1. Design Suggestions 2. Monitor the product development 3. Influence changes in designs	Conduct reviews based on Serviceability tool	1. Conduct reviews based on Serviceability tool 2. Sign-off the final designs	Prepare the after-sales organisation and the spare parts		
Product Support Targets			Maintenance Repair Usability Upgrades Cost-of-ownership	↔ No design targets					

Table 13: Summary of findings on Automotive Company

Table 13 shows that although the development of both products A and B was based on a similar product development process, several differences on the involvement of product support in the product development processes were identified.

For the Product A, the product support department had set targets mainly for the maintenance, the reliability and the cost of ownership. But these targets were not transformed into design goals for the Product A. The impact of the manager responsible for the product support at these early stages was limited. The product support personnel assisted the designers and monitored the development, making suggestions and trying to affect the product designs wherever possible. During the Field Tests stage, the usage profile of some customers was somehow ignored, leading to the subsequent problems with the product in the field.

In contrast to Product A, Table 13 shows that there was much more involvement of the product support personnel in the product development process for Product B, setting targets for many product support elements and converting them into design goals. It is important to note the existence of the Service Strategy document right at the first stages of the product development. The audit of the designs with the use of the serviceability tool (1250 items list) was very important, as this helped them promote their suggestions much easier to the designers and thus succeed to make design changes based on their requirements. It is also important to emphasise that changes over the product design were made during the Field Tests phase, due to the involvement of the product support in the tests.

From the above, one can see that several differences on the involvement of product support in the product development processes for the two products have been found. Those differences can be observed easier on Table 14.

Stage	**Differences in actions taken during the development of Product B comparing to the Product A**
1. Ideation	No differences
2. Strategy	Create the service strategy, with individual strategies for diagnostics, repair, service, spare parts for the Product B
3. Business Plan	More service targets including: repair, upgrades (the accessories offered) and usability for the Product B
4. Product Design	More design goals: cost of service and cost of repair goals. Serviceability tool (1250 serviceability items to check the Product B's designs against). This list was used as a basis for influencing design changes.
5. Prototype Testing and 6. Field Tests	Conduct reviews based on serviceability tool (on Product B)
7. Launch Preparation, 8. Production Ramp-up and 9. Launch	No differences

Table 14: Main differences between the two products

As seen in Table 13, both of the products have been through similar product development processes. Managers' perceptions (Table 7) show that product support elements are more important for the Product A (professional vehicle) than the Product

B (retail car) and those perceptions are further supported by the document quotes in Table 10. For some reasons, however, it is the Product B that is performing better in the product support elements. The main reason might be the reduced input of product support during the early stages of the NPD process and the Field Tests stage of Product A. This reason seems to have a big impact on the reliability of the Product A and was confirmed by two upstream managers during follow-up interviews. During the Field Tests stage, the product should have gone through real conditions testing, fully loaded and in several terrains. It appears, though, that this did not happen, leading to a series of problems with the product after its launch, and therefore a reduced performance in reliability, which had a big impact in its overall performance on the product support elements. The earlier involvement of the product support in the product development process for the Product B has lead to the creation of a product that, according to the managers' comments and the performance data, had better performance on the product support elements.

4.8. Issues To Resolve In The Main Study

At the end of this pilot case, all validity criteria were examined in order to identify potential problems and to seek action before embarking with the rest of the cases. The result of the examination is presented in the next page (Table 15). The main criterion that was problematic was the internal validity, due to the different nature of the products and their availability in the marketplace. All these issues were taken into account when the next cases were conducted.

Criteria	Action taken in the research design	Further issues encountered	Conclusions for further cases
Construct validity	— Constructs taken from previous studies — Pilot study conducted	— Some constructs were named differently in the case company (e.g. product support was called customer service)	— Future cases should be able to link the original constructs with those used by companies
Internal validity	— Consideration of rival explanations — Multiple sources of evidence — Feedback was be given to the informants in the form of presentation — Use of terminology employed in Automotive company, for better communication with respondents	— No negative evidence has been found — Products were not easily comparable — Performance data not directly comparable — Data not collected from customers of Product B	— Look for negative evidence — Products should be similar in nature and in target markets — All products should be in the markets for at least one year
External validity	— Multiple cases — Diverse sample of interviewees	— Threats to generalisability. Findings cannot be generalised to the automotive sector.	— The replication logic (e.g. similar research objects) of this study might reduce the generalisability threat
Reliability	— Case study protocol — Case study databases — Quality checks made for bias and informant knowledgeability	— Access to customers (one of the sources of data was given with scepticism).	— Negotiations and compromises should be made where access to customer is difficult to get

Table 15: Validity and reliability issues to be solved

CHAPTER 5. CASE STUDY – ELECTRONICS COMPANY

5.1. Introduction

In chapter 5, the findings from one of the main case studies will be presented. The section starts with a description of the data sources used for the data collection phase, continues with a reference to the organisation of Electronics Company and the NPD process employed, and concludes with the overall comparison of the involvement of product support in the development of the two products.

5.2. Data Sources

The focus of the study is to investigate the involvement of product support in the NPD process of two products in Electronics Company. The methods employed for the data collection phase are:

- *Interviews*. The managers involved in the development of two products, one that was easier to support than the other, were selected for the interviews. The interviews contained questions regarding the involvement of product support in the NPD processes for the two products and issues they would be aware because of their positions in the company. In addition to the managers, a key customer was interviewed, giving their experience with both product A and B. The managers' positions and the referencing system used in the paper are displayed in Table 16.

Interviews	Length	Reference
Technical Product Manager	1 1/2h	$I_{el1StrategyM}$
Technical Support Manager	1 1/2h	I_{el1CSM}
Service Engineer	1h	$I_{el1ServiceEngineer}$
Manufacturing manager	1h	$I_{el1ManufacturingM}$
Product Manager	2h	$I_{el1MarketingM}$
Manager of the ink system development group	1 1/2h	$I_{el1NPDM}$
Customer 1	1h	$I_{el1Customer1}$

Table 16: Interview sources in Electronics Company

- *Product Review Interview*. The product review was conducted with the help of the Product Manager (Table 17 for reference). This manager was fully aware of the support performance of the two products and responded to questions regarding the tasks and the relative difficulty of the tasks undertaken by the support personnel in each product.

Product Review Interview	Reference
Product Manager	$PR_{el1MarketingM}$

Table 17: Product review source in Electronics Company

- *Company Documents*. Another source of evidence was the Master Document List (see Appendix 8), an instrument used to retrieve the documents, required

for the research, from the company's library and the managers' files. These documents collected covered the NPD process, the product specifications, the reviews and some performance post-launch measures. The documentary sources found are presented in Table 18.

Documents	Reference
Competitive Analysis	D_{el1CA}
Market Research	D_{el1MR}
Market Requirements Specification	$D_{el1MRSD}$
Product Specification	D_{el1PSD}
Design Reviews	D_{el1DR}
Defect Log List	D_{el1DLL}
Sales and Service Report	D_{el1SSR}
Sign-off Document	D_{el1SOD}
Gate Reviews	D_{el1GR}
Minutes from Meetings	D_{el1MM}
PCP Process Document	$D_{el1PCPPD}$
Customer Usage Costs Document	$D_{el1CUCD}$
Product Manual	D_{el1PM}
Reliability Report Document	D_{el1RRD}
Warranty Document	D_{el1WD}

Table 18: Documentary Sources in Electronics Company

The referencing system used in the previous case was also employed in this case. The system is presented in Tables 16, 17, and 18, showing both the source (i.e. interviews, product review, documents) and the reference code allocated to each particular source.

5.3. Company Organisation

Electronics Company is a leading electronics company operating with an annual turnover of over £150m a year. Their main products are printers used for industrial purposes in more than 100 countries worldwide. The company has 1500 employees, with 80% working outside the UK. Product development takes place both in Europe and the USA.

The overall organisation structure of the company is shown in Figure 10. In Electronics Company, the board of the company is comprised of 9 members, five of which are non-executive members. The customer support personnel, who currently focus primarily on product support rather than the whole notion of customer support, report into operations, as illustrated below.

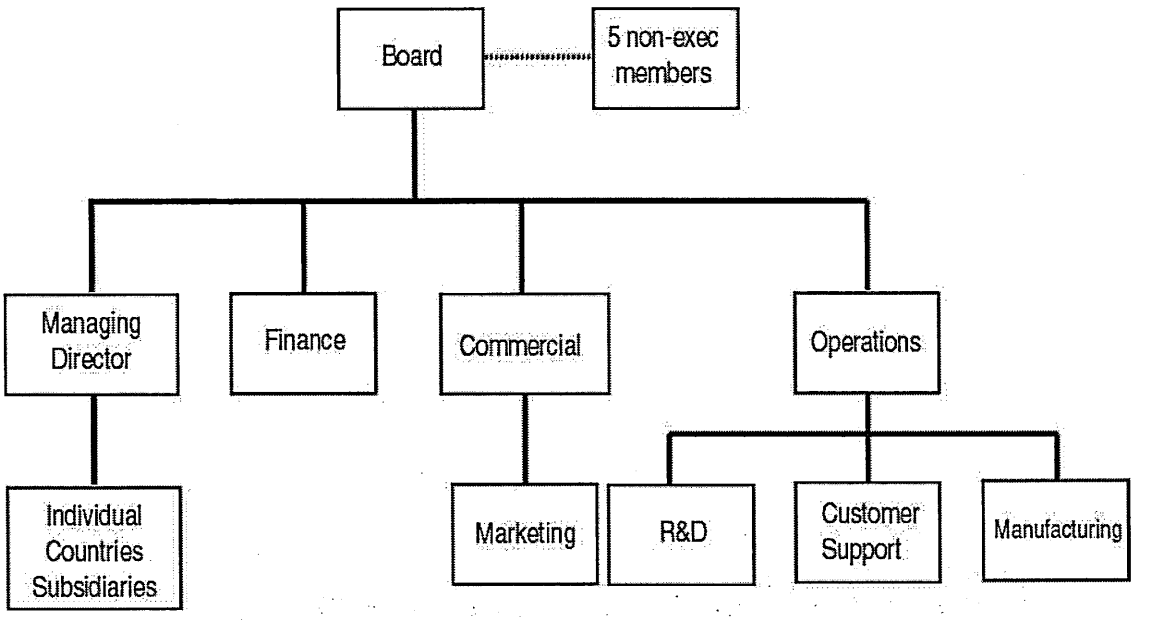

Figure 10: Position of customer support in Electronics Company's organisation

5.3.1. The role of product support in the company

The product support department is represented indirectly at the Managing board by the Operations manager (see Figure 10). One could, hence, argue there is still work to be done for product support to be a leading part inside Electronics Company. I interviewed five managers of the Electronics Company about the role of product support in the company.

The manufacturing manager commented on the past of product support:

> "*We have always looked at reliability, but we've never looked at the total costs in the whole of our supply chain, what it costs to keep up a product going...Now we would look for additional functionality into the product that helps, for example, a customer fix the product instead of us having to send a service engineer, because that is a huge cost for us*" (Iel1ManufacturingM).

The manager for the ink system development group agreed that product support was:

> "*Originally, seen as a very purely technical thing...But now it has gone full circle... it is seen not only as a means of ensuring customer satisfaction but also providing input into the new product development*"..."*Yes, it does* [play a leading part]" (Iel1NPDM).

Both managers, hold similar views, in that they both describe the past of product support as not successful but portray its present as very promising. The product manager also replied with an absolute "Yes", when asked if product support is perceived of having a leading part in the company. However, in contrast to the previous two managers, he expresses the concern that product support has not yet reached its full potential as a department.

> "*Certainly we are not as good as we could be at giving that level of feedback, as we know we would like to, resource limited basically. It is a nice to do on everyone's list*" (Iel1MarketingM).

The other two managers, the technical product manager and the technical support manager, seem to be more 'pragmatists'. They argue that product support never held a leading part in the company and criticize the department of never being so far ahead as it would be expected.

> "*I don't believe it is at the moment... from the management perspective the service figures always look bad, it always looks like you have a lot of people, very high overhead cost, doing a lot of what appears to be free of charge work, they are not generating revenue...I think service should be far more ahead than we do*" (Iel1StrategyM).

The technical support manager characterises the company's view of product support as:

> "*An unfortunate side product*" and "*a necessary evil*" that "*the company could do without from a senior level*". But he states that "*they have to put up with it, yes now they have to put more attention to it, I think they would like to not have to do that*" (Iel1CSM).

In their interviews, the managers hold controversial views on the role of product support in the company and its need for improvement. Nonetheless, they all seem to believe that product support should hold a leading role in Electronics Company. But why should it be important? How important is product support for the customers?

5.3.2. Importance of product support

All managers agreed that providing after-sales service to the customers is important for the customers. To give two illustrative examples, the manufacturing manager emphasised the importance of product support issues to customers in her comment: "*I think they* [service and support issues] *are hugely important*" (Iel1ManufacturingM) and the technical support manager added: "*I think they are very important in as much as if it* [product support] *is wrong in the first place it impacts on them*" (Iel1CSM).

One of the customers interviewed agreed that it was important and commented that:

> "*If we don't get the support and service from the company, if these things break down you can't produce at the end of the day*" (Iel1Customer1).

More detailed views about the importance of each of the customer support elements are presented in Table 19.

Elements of Product support*	Applicable	Case Study Data
Installation	Yes	"*Installation is important but not that much*" (manager of the ink system development "*It is fairly important to them*" (service engineer)
Training	Yes	"*Training is really key for a lot of things, if you have a well trained customer, you hardly hear from him because he knows all about the machine*" (service engineer)
Usability	Yes	"*Where you do tend to differentiate on are things like ease of use... the less attention thing is probably more important to the customer*" (product manager)
Reliability	Yes	"*What they need from our product is huge amounts of reliability*" (manufacturing manager) "*Reliability is a big thing in their eyes...if you don't get the right product, it can be very unreliable, it can be very messy*" (technical support manager)
Serviceability	Yes	"*When the product does break, that it can be fixed very quickly, with the minimum intervention*" (manufacturing manager)
Field Organisation	Yes	"*If they have a problem, we've got to give them confidence that we are addressing it and we understand it*" (manager of the ink system development) "*I think for a lot of customers response time is critical*" (technical product manager)
Spare Parts	Yes	"*It is important as an element but not that much*" (technical support manager)
Documentation	Yes	
Maintenance/ Preventative Maintenance	Yes	"*We have to have preventative maintenance strategies available to the customers*" (manufacturing manager)
Repair	Yes	"*Minimise the amount of unplanned service or breakdown repair that the product might need*" (manufacturing manager)
Upgrades	Yes	
Online Support	No	
Cost of Ownership	Yes	"*Customers would assess the main competitors in the marketplace and look at the total cost of ownership rather than the purchasing price*" (manufacturing manager) "*People do worry about cost of ownership, they want to know how much it's going to cost running that machine*" (technical support manager)

Table 19: Product support elements and their importance to Electronics Company customers

*Based on Goffin (1998)

5.4 Company NPD Process

The stages of the product development process and the subsequent review meetings (i.e. the gates) in Electronics Company, for both products A and B, are illustrated in the figure below.

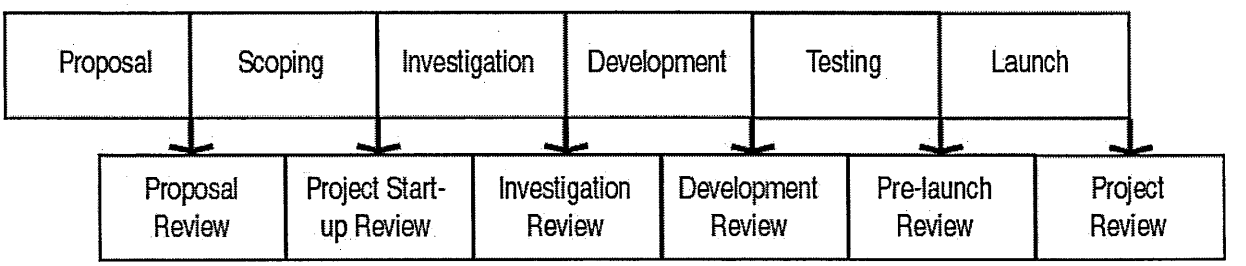

Figure 11: Product development process in Electronics Company ($D_{el1PCPPD}$)

This data was retrieved from the company's Product Creation Process (PCP) Document and describes accurately the process that was followed for the new products development. Six stages are included in this process:

- ***Proposal:*** *New product or process development idea.*
- ***Scoping:*** *Acquire additional information.*
- ***Investigation:*** *Compile specifications and complete market and technology assessments.*
- ***Development:*** *Complete designs and bills of materials. Manufacturing plan, launch plan, technical publications.*
- ***Testing:*** *Show that product meets specifications and that processes are capable.*
- ***Launch:*** *Monitor project performance against key performance indicators. Identify outstanding support issues.*

For the development of product A, the manager of the ink system development group described the type of the organisation as matrix with different departments participating in the NPD team.

> "*For this particular project it* [type of organisation] *was matrix... In Product Development you have marketing, the marketing interface between sales and development and the customer, the manufacturing engineering, all the development functions, mechanical, electronics, software, ink system and purchasing as well*" ($I_{el1NPDM}$).

The organisation on product B was project-type, with the core NPD team consisting of the same departments as in the Product A.

> "*It was project* [type of organisation]... *The manufacturing was involved, service, sales, marketing*" ($I_{el1NPDM}$).

5.5. Choosing The Two Products

The two products selected to investigate the involvement of product support in the NPD process were two different versions of an inkjet printer:

i. An old version of the printer (Product A)
ii. The latest version of the printer (Product B)

Both products are installed at the end of production lines on customer sites and the cost for the customer companies, when they products cannot operate properly ("downtime"), is considerable (when the printer stops so does the production line).

5.5.1. Product selection

5.5.1.1. Interviews with product support personnel

At the beginning of the case study the company's service engineer and the technical support manager were asked to indicate an easy and a difficult to support product. They both indicated product A as difficult to support compared to product B which was considered an easier to support product.

5.5.1.2. Documentary evidence

The views of the engineer and the manager were supported by the performance data (collected from the company's documents) on product support for the two products. This data is presented in Table 20.

	Product A	**Product B**
Cost of Ownership (over 5 years)	100* ($D_{el1MM/A}$)	88* (servicing costs lower, consumables lower than Product A) ($D_{el1MM/B}$)
Number of Components	1600 ($D_{el1PM/A}$)	600 ($D_{el1PM/B}$)
Mean Time Between Failures (MTBF)	2200 hours ($D_{el1RRD/A}$)	3500 hours ($D_{el1RRD/B}$)
Time to carry out routine 2000hr service	6.5 hours ($D_{el1RRD/A}$)	2.5 hours ($D_{el1RRD/B}$)
Warranty cost in first year	100* ($D_{el1CUCD/A}$)	57* ($D_{el1CUCD/B}$)
Average Installation Time	8 hours ($D_{el1MM/A}$)	6 hours ($D_{el1MM/B}$)

* = Index numbers (actual figures confidential)

Table 20: Performance of the products on product support (Source: Product support department)

Table 20 shows on the left hand-side column the measures for product support used in the Electronics Company. The middle and right hand-side column illustrate the performance of product A and B respectively. A first comparison of the two products shows that product B is cheaper to operate (88 vs 100), is faster to install (6 vs 8 hrs), service (2.5hrs vs 6.5hrs), is more reliable (MTBF: 3500hrs vs 1600hrs) and less complex than product A (600 components vs 1600). This last element might have had an impact on its product support performance, as a less complex product is an easier to service product.

5.5.1.3. Product review interview

When the two products were examined together with the product manager, several key differences in the designs were identified during the product review interview ($PRel1_{MarketingM}$). Specifically, product A included a part that, if failed, it was not possible to ascertain whether it had failed or not. Especially, when it came to the quality of printing, one could not identify whether the problem was with that part of the printer or something else (i.e. another part or the ink). The design of product B on the other hand was different, as it included switches and warning lights for that part, thus making

the diagnosis of the problem far easier (thus reducing the time to carry out the service shown in Table 20). Product B had also a more effective user-interface, different keyboard (the functionality of the product A was not that good), and was more 'user-friendly' than product A.

5.5.2. Launch dates

Product A was launched in the market in 1994. The basic idea of the product was not new, as it was based on various previous versions of the company's printers. The only difference between the product and its predecessors was, according to the technical product manager that "*it could operate in tough working environments*" (Iel1StrategyM), as it had high dustproof and waterproof ratings (based on a British Standard). Whilst, product B was launched in the market in 1999 and it was a totally new product in the market.

5.6. NPD Process Stages For A and B

5.6.1. Proposal and Scoping

In these first two stages of the NPD process (shown in Figure 11), the idea of the new product is developed and decisions about the strategy to be followed are made. The product support department was represented with a product support manager in the core product development team from the beginning of the design of both products. For product A, the product manager, who at the time was the Product Support Manager, recalls: "*In those days I was involved with the technical support and in that role I was in the project team...I was part of that all the way through*" (Iel1MarketingM). The technical support manager also comments on the same lines: "*One of the people that was there was from the support department*" (Iel1CSM). Similarly, for product B, the manager for the ink system development group observed: "*We did have a technical support representative in the team*" (Iel1NPDM).

The input of the product support managers at these early stages of NPD was to provide the team with "*their experience on the problems we had with the old systems*" (Iel1NPDM) and to "*feed in field issues*" (Iel1ManufacturingM) as the manager for the ink system development group and the manufacturing manager commented respectively. "*People expected us to bring in the history of where we are, so we can say well, this is what led us to where we are today, and if you do this, this is going to do better, worse or have no effect*" (Iel1CSM).

The technical support manager's comment on the input of the product support representatives at the early design stages of the products might suggest that they did not influence directly the decision-making. They rather provided historical info about the problems with existing products in the field.

To find supportive evidence of the involvement of product support in the design process documentary evidence was reviewed. The documents reviewed were:

- The Competitive Analysis document. A review of the competitors' products in the area of inkjet printing in production lines
- The Market Research. Customer preferences, mainly focused on the functions of the products rather than total product-service packages.
- Minutes from Meetings

The findings for this stage can be summarised in the following diagram (Figure 12).

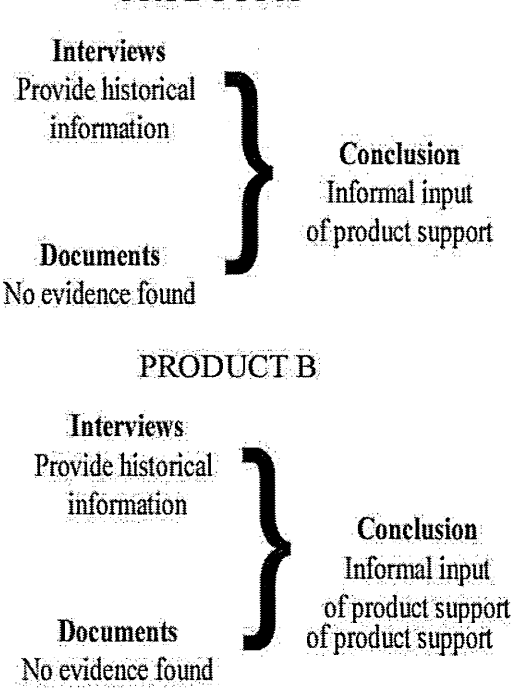

Figure 12: Findings of Proposal and Scoping stages for both products

In the interviews, managers agreed that product support would provide the team with experience on the problems with previous products. On the documents, however, there is no history listing. No support for their claims was found. Consequently, in the absence of any evidence one might argue that perhaps the input of product support was much more informal than the managers suggested in their interviews for these early stages of the NPD process for both products.

5.6.2. Investigation

In this stage, the development team sets the product specifications (e.g. operational environment, functionality, speed of printing etc.). The specifications are recorded in two documents: a) the 'Market Requirements Specifications' document (Del1MRSD) and b) the 'Product Specifications' document (Del1PSD). The former document refers to design targets relevant to the customer requirements. The latter, refers to engineering requirements. Both documents were reviewed for information on product support input in the investigation stage for products A and B. this information is presented in Table 21.

Product Support Elements*	Product A		Product B	
	Performance	***Design Target***	***Performance***	***Design Target***
Installation time	8 hours (I_{el1CSM}, $D_{el1MM/A}$)	–	6 hours (I_{el1CSM}, $D_{el1MM/B}$)	–
Usability	–	–	–	"It is desirable to address all products from a single-point for operator ease of use… Increase operator ease of use…8 languages" ($D_{el1MRSD/B}$)
Repair	MTBF: 2200 hours ($D_{el1RRD/A}$)	MTBF: 5000 hours ($D_{el1PSD/A}$) Product lifetime: 10000 hours or 5 years ($D_{el1MRSD/A}$)	MTBF: 3500 hours ($D_{el1RRD/B}$)	"Not to compromise reliability" ($D_{el1PSD/B}$) Product lifetime: 10000 hours or 5 years ($D_{el1MRSD/B}$)
Maintenance	Number of components: 1600 ($D_{el1PM/A}$) Time to carry out a routine 2000hr service: 6.5 hours ($I_{el1ServiceEngineer}$, $D_{el1RRD/A}$)	Service intervals: 2000 hours ($D_{el1MRSD/A}$) Items to be serviced ($D_{el1MRSD/A}$)	Number of components: 600 ($D_{el1PM/B}$) Time to carry out a routine 2000hr service: 2.5 hours ($I_{el1ServiceEngineer}$, $D_{el1RRD/B}$)	"Same electronics and software with previous products in order to minimise re-training of the service personnel… Increase parts commonality" ($D_{el1PSD/B}$) Service intervals: 2000 hours ($D_{el1MRSD/B}$) Items to be serviced ($D_{el1MRSD/B}$) Service Time ($I_{el1NPDM}$)
Cost of Ownership	Warranty cost in first year: 100** ($D_{el1WD/A}$) Cost of Ownership over 5 years: 100** ($I_{el1MarketingM}$, $D_{el1CUCD/A}$)	–	Warranty cost in first year: 57** ($D_{el1WD/B}$) Cost of Ownership over 5 years: 88** ($I_{el1MarketingM}$, $D_{el1CUCD/B}$)	–

Table 21: Comparison of Performance and Design Targets

Note: Blank cells show that no document or interview quotes existed for those elements of product support

* Based on Goffin (1998)

** Index numbers

For product A, the key targets found for product support elements were the 'Mean Time Between Failures' (MTBF), the 'Product Lifetime', the 'Service Intervals' and the 'Items to be Serviced' (see Table 21). Only four targets for product support elements seem as an extremely limited number compared to the over 30 targets that could be set at this stage as suggested in the literature (Van Bennekom and Goffin, 2002). 'Service Time', 'Cost of Ownership', 'Installation Time' were all performance measures, recorded after launch, but not set as design targets for product A. The limited involvement of product support, at this important stage of product development where the specifications are set, is admitted by the manager of the ink system development group and the technical support manager in their interviews:

> "*It was accepted that they would have 2000hour intervals, the serviceable items were specified but that was all there was. There were not other targets apart from that...the next stage where they would have an input is on the signing off of the development phase when they are happy with it*" (Iel1NPDM).

> "*Interestingly, I don't think specifications were really thought through, because the interface was done on-the-fly, basically the software was written and somebody said 'well, you've got to interface with it' it was a lot messier than we have today*" (Iel1CSM).

Therefore, with the evidence of both interviews and documents supporting one another, one can conclude that no strong influence of support on the development project was found at this phase of the NPD process for product A. For product B, the technical support manager's comment "*it was a lot messier than we have today*" (Iel1CSM) perhaps suggests a change in the product support input. The product manager seems to agree. He argues that the setting of the specifications in Product B was done under some influence from the product support personnel:

> "*They were involved in setting targets in the specification. They didn't make decisions but they influenced them*" (Iel1MarketingM).

The manager of the ink system development group mentions that a new target was set for product B: "*There was service time*" (Iel1NPDM). However, this target was not confirmed by documentary evidence. However, a target for 'Time Between Services' was developed and recorded in the specifications documents.

Product support had set as a target to "*increase operator ease of use*" (Del1MRSD/B) for product B. Usability was not mentioned by any manager in their interviews. This perhaps suggests they did not consider 'usability' a product support element. In the Product Specifications document, product support clearly state that they do not want to "*compromise reliability*" (Del1PSD/B) and aim at "*an increase of parts commonality with previous products*" (Del1PSD/B) – thus minimise the re-training of service. Reliability was again a product support target recovered from the documents that was not mentioned in the interviews. Perhaps the managers regard reliability mainly as an engineering target.

A summary of the findings for both products at this stage is show in Figure 13.

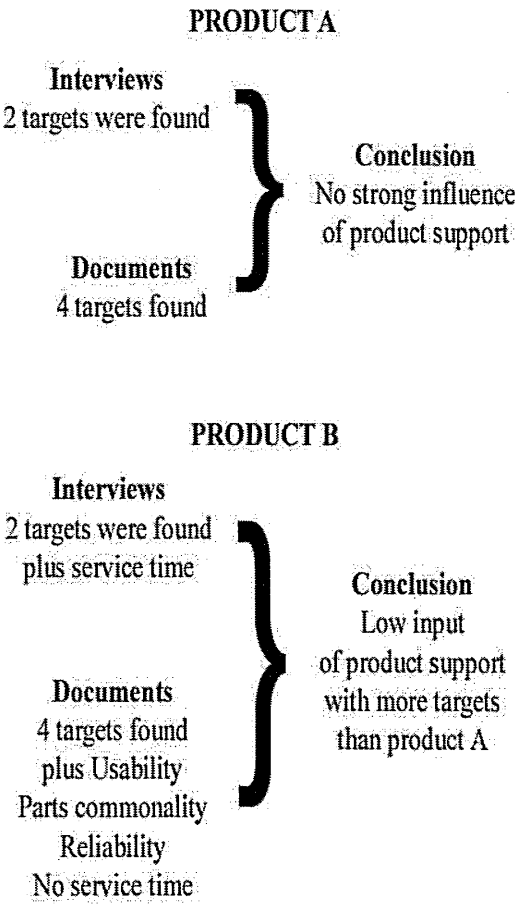

Figure 13: Findings of Investigation stage

Overall, more design targets were found in the documents than mentioned in the interviews. The evidence from both interviews and documents shows that more product support design targets were set for product B (see Table 21). The number of design targets set for both products A and B at the Investigation stage is relatively small, compared to the number suggested by the literature and the performance data collected after launch. This comparison of data supports the view that in the Investigation stage product support had a relatively small input in both products, with product B having slightly more design targets than product A. The issue then is whether these limited design targets were or not transformed into design goals in the Development stage. This will be discussed in the following section.

5.6.3. Development

The detailed designs of the products are developed at this stage. At the development stage, the design targets, defined by the product support and the engineering requirements, are translated into design goals. The input of product support becomes apparent at this stage if the design targets for product support are translated into design goals and used for the evaluation of the product design.

For both products A and B, the product manager reported that the product support personnel "*were present at all the design review meetings, they participated, they had peer group design reviews, almost invariably there was a field representative joining all those processes to feed back about service* " (Iel1MarketingM). Product support people participated in the design review meetings. But, was product support actually taken into account in the development stage?

For product A, the manager of the ink system development group commented that "*product support was not taken into account when designing the Product A...the design for service was not very well done at the product A, really*" (Iel1NPDM). The technical support manager reinforced this view: "*I remember sitting with the technical manager in those days, we were looking at servicing but not necessarily designing it for service*" (Iel1CSM).

At the end of the development stage, an evaluation of the product design was compiled. Interestingly enough, the manager of the ink system development group reports in his interview that this evaluation was based on "*no specific goals*" on the part of the product support: "*No we did not have any goals for the service at this stage...The evaluation of the product design*", he observes, "*was rather laid on the development team*" (Iel1NPDM).

The minimum input of product support is also confirmed in the 'design review first prototype' document (Del1DR/A). This document was a first review on the actions taken for the design of product A and states that:

> "*Although consideration was given to the service requirements, no direct input has been sought*" (Del1DR/A).

For product A, findings from both the interviews and the documents suggest that the involvement of product support at the development stage was minimal and perhaps further moved into the development project.

As far as the design of the product B is concerned, the product support did offer some input. This was pointed out by the manager of the ink system development group: "*The problem with the old system was that there were no diagnostics at all...with the product B there were some sorts of alarms, alerts...to point out serious malfunctions...these changes are due to the input from the field engineers*" (Iel1NPDM). However, he observed: "*I think there were no particular goals*". The design of product B was "*mainly driven by manufacturing*" (Iel1NPDM).

Regarding the evaluation of the product B, at the end of this stage, the technical support manager stresses "*No, I don't think we had any goals, not really...there were not any actual goals in terms you should actually service it in the X amount of time...it was more to make sure that we didn't do it any worse*" (Iel1CSM). As in the case of product A, no product support goals were set in the evaluation of the product B design.

No comments were identified in the 'Design review' document for Product B (Del1DR/B) regarding the product support input and its involvement in the product design. That was rather expected given that no explicit product support design goals were set for the evaluation of the product at this stage.

The documentary and interview evidence found for both products are shown in Figure 14.

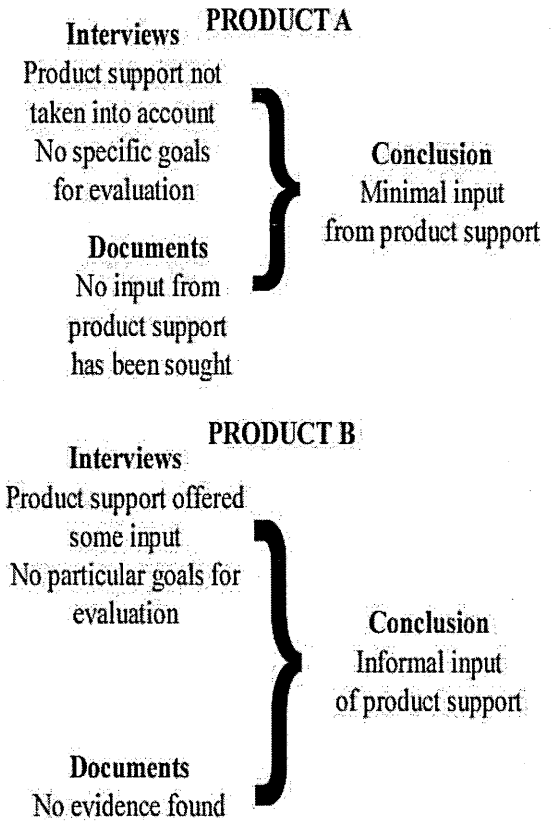

Figure 14: Findings of Development stage

Based on the evidence, or the absence of evidence, in the interviews and in the available company documents, it would be fair to argue that there was some involvement of product support at the development stage of product B but it was not set clearly and explicitly. None of the design targets set in the Investigation stage were translated in this stage to design goals for product support. However, the alerts for malfunctions, as reported on the interviews, did not come out of the blue. In that sense, product support involvement in the development stage was rather informal and had affected the product design in an implicit, indirect and tacit manner.

5.6.4. Testing

At this stage, the product prototypes undergo laboratory and field trials in order to assess the functionality of the final product together with other marketing and engineering aspects.

For product A, prototypes were developed at this stage and put into testing conditions, or field trials. The Manufacturing Manager quoted: "*They went out in field trial...a six-week* [trial] *to see how they* [the products] *work and how they stand up to real battering*" (Iel1ManufacturingM).

A prototype of product A was tested "*in different factory environments...to see that it actually performed in a way that we expected it to perform*" (Iel1ManufacturingM). She continued: "*Anybody can probably design an inkjet printer that runs in a lab very easily, but getting one to run when it is 45 or 90% humidity, with saw dust in the air and everything else is a very different story...Because we can't simulate those*

conditions in-house...we try to put our products in those environments before we release them" (Iell1ManufacturingM).

So, "*The functionality was the primary driver*" of the development team (Iell1ManufacturingM). The technical support manager commented that product support did not provide any input in the tests: "*There was nobody giving input on any side of the printer unless something happened that it was bad. We tended to be close to launch in those days*" (Iell1CSM).

An analysis of the available documentation ('Minutes from meetings', 'Design reviews', 'Gate reviews') found no references to the product support input in the testing stage of product A.

On the contrary, for Product B, the technical product manager commented: "*On the product B,* [product support] *were involved much earlier in the product development than with the Product A, where they were involved much later*" (Iell1StrategyM).

Apart from the functionality tests described for product A, the second product had to go through an additional phase, the validation phase. This took place 6 months before the launch of the product in the market and, according to the manager of the ink system development group, its main purpose was "*to stress the product out to see whether it meets the customer requirements*" (Iell1NPDM). The manufacturing manager explains about this process: "*Product B was the first product we properly validated... part of the validation process is to put the product inside customer sites*" (Iell1ManufacturingM).

The technical product manager commented on the input of product support: "*I know that the Technical Support provided a lot of input at that stage to refine the design to make it better for the service engineers*" (Iell1StrategyM). The input of the product support department was based on a document, "*a bugs list or Defect log*" (Iell1ManufacturingM), which included a list of problems with the design of the product: "*As they go through the process they would raise those* [issues] *and they would all be recorded and issues customers have given to them*" (Iell1ManufacturingM).

This 'Defect log' list (Dell1DLL/B) is an important document. It enabled product support to focus their actions when testing the product and also helped them influence changes over the design. The technical support manager gives an example of a design change resulting from the product support efforts: "*It actually involved the service team and service people to come in and try out their design...if anything was wrong they would then look at the design to accommodate the service*". For example, "*during the validation we couldn't change it* [a part] *in one and a half hours and we decided we couldn't do it, and the design was changed*" (Iell1CSM).

Another relevant document reviewed at the testing stage was the 'Sales and service report' (Dell1SSR/B). This report included all the product support findings from the validation stage. However, its content did not relate to the involvement of product support in the process. It rather reported on the service requirements and the functionality of the product B in different environments with no direct relevance on the actions taken by product support at the Testing stage.

The findings for both products A and B can be summarised in the following figure (Figure 15)

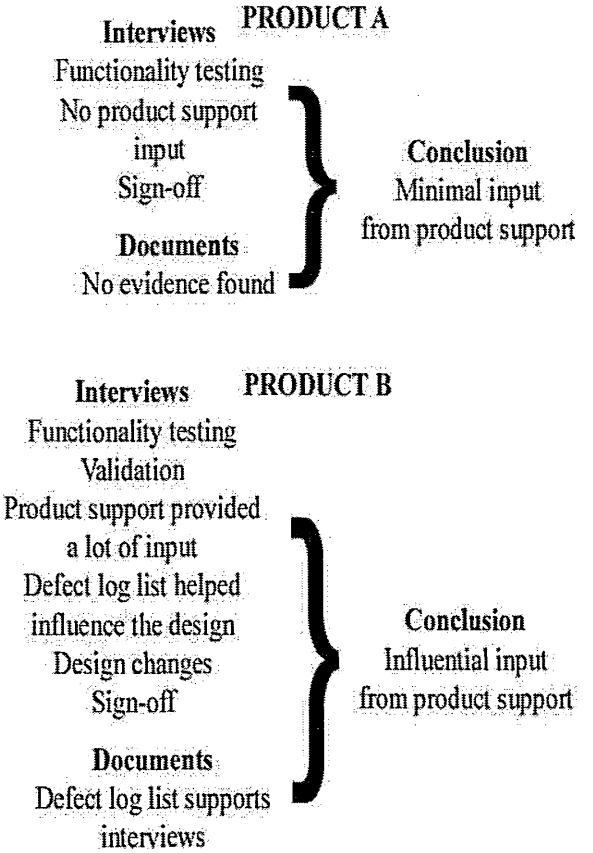

Figure 15: Findings of the Testing stage

Based on the views from the managers and the absence of evidence of product support involvement at this stage for product A, one could conclude that the input of product support was fairly minimal at this stage for this product. In the case of product B, part of the documentary evidence and the interviews did reveal a considerable amount of input from product support in the design of this product at the testing stage. Product support personnel did not only test the product to their requirements before its launch, but had also achieved to change the design in order for the product to meet their specific requirements.

At the end of the Testing phase, as part of the engineering sign-off, the product support had to sign-off for the final designs of both products. For product A, the manager of the ink system development group mentioned: "*The next stage where they* [the product support] *would have an input, apart from the specifications, is on the signing off of the development phase when they are happy with it*" (Iel1NPDM).

For product B, the product support had to sign-off the validation phase in addition to the signing-off at the end of the testing stage: "[Product support] *signed off the validation as well...so the validation is the most important thing for them, because that confirms that it meets the customer requirements*" (Iel1NPDM).

In general, the input in the product A was fairly limited. Product support only signed off the designs just before launch. For product B, the technical support manager notes that input from product support "*was still later on, it was still 'here is the*

product"(I_{el1CSM}). But compared to product A, product support input came earlier in the process. This time: "*at least they listened before it went out*"(I_{el1CSM}). Providing input earlier in the stage (i.e. in the validation phase) and focusing on the serviceability side of the product B had actually led to changes over the designs before entering the production phase. The technical support manager maintains that this resulted in the creation of a product that was easier to support in the field: "*We were involved in the serviceability of it...we've been through the validation to check all that, so it is a lot better* [than product A]" (I_{el1CSM}).

5.6.5. Launch

After the sign-offs of the final product designs, both products entered the Launch phase. In this stage the final product designs are transformed into the physical products in high volume production lines and then launched in the market. At Launch, product support had to arrange the after-sales organisation and the spare parts provision.

When asked to identify the role of product support in the 'Post Release Problem Resolution and Product Improvement' phase four out of five managers classified product support as being among the decision makers for both product A and B (for this interview question instrument $ISTR1_{MAN}1^{A}$ and $ISTR1_{MAN}1^{B}$ were employed).

According to the technical support manager, the product support personnel "*were now responsible for all field problems with the products, i.e. the spare parts provision, the dispatch of service engineers in sites where problems with products have occurred etc*" (I_{el1CSM}) for both products.

In the following section, a comparison of the two products on the involvement of the product support in the New Product Development process will be presented.

5.7. Summary Of Findings

The development of products A and B was based on similar product development processes. However, the involvement of product support in the product development processes of the two products varied. Tables 22 and 23 illustrate the involvement of product support in the NPD process for product A and B respectively.

Product A:

NPD Stages	Proposal	Scoping	Investigation	Development	Testing	Launch
Timescale	Start 1993	Start 1993	Mid 1993	End 1993	Mid 1994	End 1994
Product Support Actions	No involvement ($D_{el1PCPPD/A}$) ($I_{el1StrategyM}$) (I_{el1CSM})	Historical Information for products in the field ($D_{el1PCPPD/A}$) ($I_{el1NPDM}$) (I_{el1CSM})	Set service goals ($D_{el1MRSD/A}$) ($I_{el1NPDM}$) (I_{el1CSM})	No involvement ($I_{el1NPDM}$) (I_{el1CSM})	Involved just before launch for the sign-off of the final product designs ($D_{el1SOD/A}$) (I_{el1CSM})	Organise the after-sales organisation and deal with field problems (I_{el1CSM})
Product Support Targets	None found ($D_{el1MRSD/A}$) ($D_{el1PSD/A}$)	None found ($D_{el1MRSD/A}$) ($D_{el1PSD/A}$)	- Service intervals - Serviceable items - MTBF - Product Lifetime ($D_{el1MRSD/A}$) ($D_{el1PSD/A}$)	Not Applicable	None found ($D_{el1MRSD/A}$) ($D_{el1PSD/A}$)	Not Applicable

Table 22: Findings for product A

One can see from Table 22 that the only service related targets set for the development of the product A were dealing with the maintenance of the product and, specifically, the service intervals and the service items. No design goals were set for the product support elements. In fact, the product support was not involved whatsoever in the design stage of the product development, not even in the initial testing phase, as stated in the 'design review first prototype' document. Product support really got involved when they had to sign-off the final product designs, just before the product entered the launch stage. About the product support involvement, the manager of the ink system development said: "*Product support would have an input on the market requirements specification because they are a customer, so they would have an input there. The design teams would then develop the product requirement specification and then... the next stage where they would have an input is on the signing off of the development phase when they are happy with it*" ($I_{el1NPDM}$).

Product B

NPD Stages	Proposal	Scoping	Investigation	Development	Testing	Launch
Timescale	Start 1996	End 1996	Mid 1997	End 1997	End 1998	1999
Product Support Actions	No involvement ($D_{el1PCPPD/B}$) ($I_{el1StrategyM}$) (I_{el1CSM})	Historical Information for products in the field ($D_{el1PCPPD/B}$) ($I_{el1NPDM}$) (I_{el1CSM})	Set service goals ($D_{el1MRSD/B}$) ($I_{el1NPDM}$) (I_{el1CSM})	Limited involvement ($I_{el1NPDM}$) (I_{el1CSM})	- Extensive testing - Influenced changes on the product designs - Sign-off the final product designs ($D_{el1SOD/B}$) (I_{el1CSM}) ($I_{el1NPDM}$)	Organise the after-sales organisation and deal with field problems (I_{el1CSM})
Product Support Targets	None found ($D_{el1MRSD/B}$) ($D_{el1PSD/B}$)	None found ($D_{el1MRSD/B}$) ($D_{el1PSD/B}$)	- Maintenance intervals - Serviceable items - Usability - Reliability - Serviceability ($D_{el1MRSD/B}$) ($D_{el1PSD/B}$)	Not Applicable	None found ($D_{el1MRSD/B}$) ($D_{el1PSD/B}$)	Not Applicable

Table 23: Findings for product B

In the case of product B, the involvement of product support in the product development process differed. Although the product support provided the same type of information in the Scoping stage, in the Investigation stage they created service targets that they would use to test the product in the Testing stage. In the 'market requirements specification' document, it is clearly stated that they wanted to create a product that should be easy to use and reliable. However, as shown in section 5.6.3, similarly to product A, those targets were not transformed into design goals. Nonetheless, in comparison with product A, product B had considerably more input from product support in the Testing stage.

Table 24 highlights the main differences in the actions taken for the development of the two products.

Stage	**Differences in actions taken during the development of product B comparing to the product A**
Proposal/ Scoping	No differences
Investigation	Request for a more user-friendly product (product B)
Development	No differences
Testing/ Validation	More extensive testing of prototypes (product B). Checked the service aspects of the product (product B). Influenced changes on the design of the product B.
Launch	No differences

Table 24: Main differences between the two Electronics products

Product B was faster to service and had increased reliability over the product A (see Table 21). By consequence, it was easier to support and had a lower cost of ownership. It appears that the earlier and higher involvement of product support in the NPD process, especially in the Testing stage (i.e. extensive testing of the product in the company's labs and in customers sites), resulted to changes to the design of product B, which made it easier to support and more competitive in the marketplace through the lower cost of ownership.

CHAPTER 6. CASE STUDY – SOFTWARE COMPANY

6.1. Introduction

In chapter 6, the findings from the Software Company case study will be presented. The section starts with a description of the data sources used for the data collection phase, continues with a reference to the organisation of Software Company and the NPD process employed, and concludes with the overall comparison of the involvement of product support in the development of two products.

6.2. Data Sources

The focus of the study was to investigate the involvement of product support in the NPD process of two products in Software Company. The methods employed for the data collection phase were:

- *Interviews*. The managers involved in the development of two products (one that was easier to support than the other) were selected for the interviews. The interviews contained questions regarding the involvement of product support in the NPD processes for the two products and related issues they would be aware because of their positions in the company. The managers' positions and the referencing system used in the paper is displayed in Table 25.

Interviews	Length	Reference
Product A Development Manager	1 1/2h	$I_{sof1NPDMA}$
Product B Project Manager	1 1/2h	$I_{sof1NPDMB}$
Senior Service Planner	3h	$I_{sof1CSM}$
Product A Manager	1h	$I_{sof1MarketingMA}$
Product B Development Portfolio Manager	1 1/2h	$I_{sof1MarketingMB}$
Development Operations Manager	1 1/2h	$I_{sof1StrategyM}$

Table 25: Interview sources in Software Company

- *Product Review Interview*. The product review was conducted with the help of the Senior Service Planner (Table 26 for reference). This manager was fully aware of the support performance of the two products and answered questions regarding the tasks and the relative difficulty of the tasks undertaken by the support personnel in each product.

Product Review Interview	Reference
Senior Service Planner	$PR_{sof1CSM}$

Table 26: Product review source in Software Company

- *Company Documents*. Another source of evidence was the Master Document List (see Appendix 8), an instrument used to retrieve the documents, required for the research, from the company's library and managers' files. These documents collected covered the NPD process, the product specifications, the reviews and some performance post-launch measures. The documentary sources found are presented in Table 27.

Documents	Reference
IPD Process Document	$D_{sof1IPDD}$
Serviceability Bucket	$D_{sof1TIPDA}$
Timeline of the IPD Project – Product A	$D_{sof1TIPDB}$
Timeline of the IPD Project – Product B	$D_{sof1PUG}$
Product User Guide	$D_{sof1PDG}$
Product Determination Guide	$D_{sof1PLD}$
Product Level Design	$D_{sof1EILA}$
Evaluation Items List – Product A	D_{sof1OD}
Organisation Diagram	$D_{sof1PDS}$
Product Determination Scorecard	$D_{sof1SRB}$
Serviceability Review Product B	

Table 27: Documentary Sources in Software Company

The referencing system used in the previous cases was also employed in this case. The system is presented in Tables 22, 23, and 24, showing both the source (i.e. interviews, product review, documents) and the reference code allocated to each particular source.

6.3. Company Organisation

Software Company is a leading infrastructure systems software company, with an annual turnover of over £5bn a year. It offers a wide range of software products and services including application development tools, commercial messaging products, database and data management, e-commerce products, networking and communications products, transaction systems and web application servers. The company has more than 8000 employees, and, depending on the product, its product development takes place in Europe, Australia, USA, and Asia.

The overall organisation structure of the company is shown in Figure 16. In Software Company, the customer support personnel report into the primary service planning, who in turn report into the development organisation, as illustrated below.

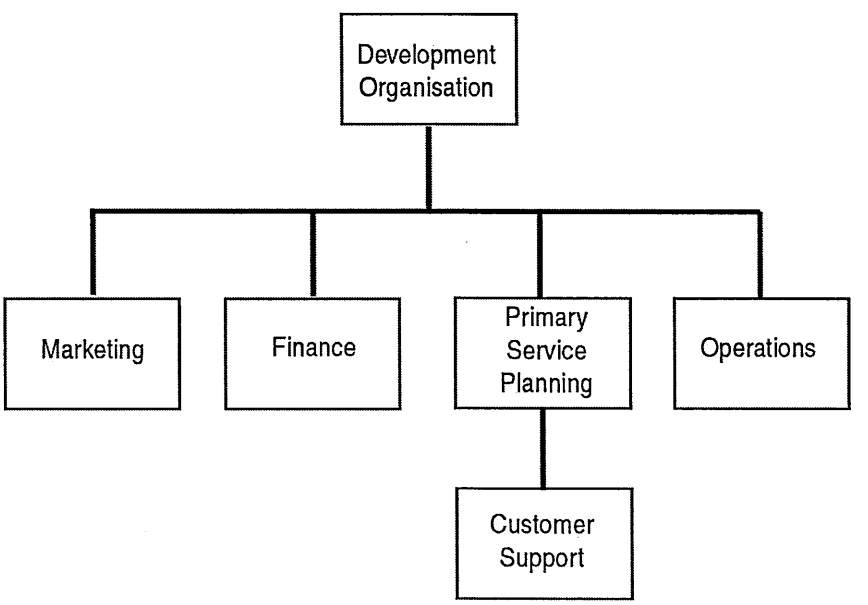

Figure 16: Position of customer support in Software Company's organisation

6.3.1. The role of product support in the company

The product support department is not directly represented at the meetings that define the strategy of the Software Company. Many of the managers agreed on the view that product support is not a leading part inside the company. For example, the Development Operations Manager's response was: "*I don't think it is particularly the leading*" ($I_{sof1StrategyM}$), whereas the Product A Development Manager said: "*I would say no*" ($I_{sof1NPDMA}$).

Although not the leading, product support is one of the fundamental parts of the Software Company: "*It is a foundational requirement... but I don't know if you would lead with it... It played a key role in an awful lot of what we do*" ($I_{sof1StrategyM}$). The Product B Development Portfolio Manager commented that, considering all factors required to run successfully a business, "[product support is considered] *at least as high as everything else*" ($I_{sof1MarketingMB}$).

Responsibility of the product support department is:

> "*to ensure that 1) we patrol, in a way, the quality of the product...what the customers want from us meet with what they expected to be. 2) For any problems that do exist, we have to ensure that the overall structure is there to fix it. 3) We have to ensure that the product or whatever service is built into it, exists before it goes out or if we missed something, to make sure that it will be sent as soon as possible to the customer. And 4) we actually track to make sure that the product has performed to what we expected to do*" ($I_{sof1CSM}$).

The key question one has to ask at this point is: Is really product support important to the customers of this company?

6.3.2. Importance of product support

The answer to the question is yes. "[Product support] *is absolutely paramount... more and more customers are going for 24 by 7...But if you are talking about any sort of big businesses, even internet businesses now, because of the global nature businesses and because it is so easy to work internationally now, especially through the web, you can't just limit yourself as a customer to 'oh, 9 to 5 in one camp shire'*"($I_{sof1NPDMB}$).

Another example of the view all managers hold is given by the Product A Manager:

> "*because we deal very much in the large end, you know, the enterprise end of the business, we are dealing with big companies that need that assurance of the large investments they are going to make, are going to be protected and they are not going to have to re-invest in a year's time or 18-month's time, they can service that investment over an extended period*" ($I_{sof1MarketingMA}$).

More detailed views about the importance of each of the product support elements are presented in Table 28.

Elements of Product support*	Applicable	Case Study Data
Installation	Yes	"*A customer has got a schedule, and that schedule costs money. The importance of him meeting that schedule is depending upon installation...*" (senior service planner)
Training	Yes	"*for new customers, that is particularly important because they want to get up to speed*" (product A manager)
Usability	Yes	"*It is getting very important [for our customers]... because they need to be sure that their systems programmer or the people that they use the applications are able to use the interfaces easily*" (product B project manager)
Reliability	Yes	"*reliability is paramount and 24/7 operation is crucial*" (product A manager) "*reliability is what they want*" (product A development manager)
Serviceability	Yes	"*they realised that serviceability is another aspect that customers are driven to buy a product*" (senior service planner)
Field Organisation	Yes	"*I think they are very important. I think that it is crucial, if they are looking for 24/7 operations and there is a problem, they need to get access.*" (product B development portfolio manager) "*I think for a lot of customers response time is critical*" (technical product manager)
Spare Parts	No	
Documentation	Yes	"*documentation is important to be thorough but it is not a crucial thing*" (product A development manager)
Maintenance/ Preventative Maintenance	No	
Repair	Yes	"*Repair philosophy... I think that it is very important.*" (product A manager)
Upgrades	Yes	"*this is an investment protection thing, that's quite important to a lot of customers, it is not like the repair philosophy but it is an evolution in installing a new software and then take the existing applications with you*" (product A manager)
Online Support	Yes	"*I think they've got a lot of in-house and telephone support, online is probably less important*" (product A manager)
Cost of Ownership	Yes	"*Cost of ownership as vital for them*" (Development operations manager) "*People do worry about cost of ownership, they want to know how much it's going to cost running that machine*" (technical support manager)

Table 28: Product support elements and their importance to Software Company customers

*Based on Goffin (1998)

6.4. Company NPD Process

The stages of the product development process and the subsequent review meetings (i.e. the gates) in Software Company, for both products A and B, are illustrated in Figure 17.

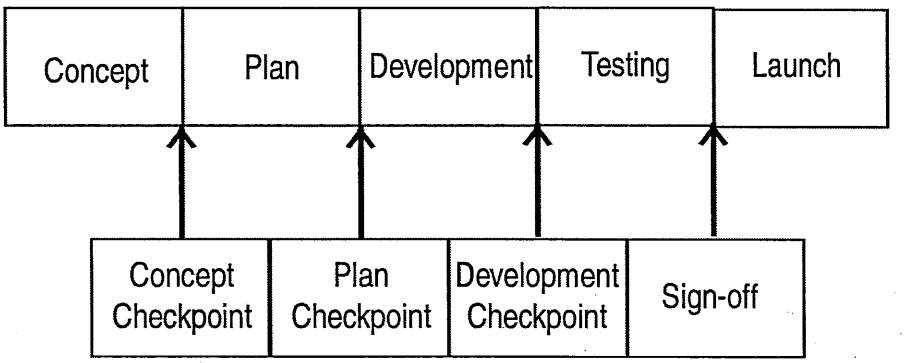

Figure 17: Product development process in Software Company ($D_{sofIIPDD}$)

This data is retrieved from the company's Integrated Product Development (IPD) process Document and describes accurately the process that was followed for the new products development. Six stages are included in this process:

- ***Concept:*** *New product idea. Decide the theme of the release.*
- ***Plan:*** *Set the product specifications.*
- ***Development:*** *Build the product code.*
- ***Testing:*** *Show that product meets specifications and that error messages are in place.*
- ***Launch:*** *Assess the project performance using performance indicators. Identify outstanding support issues. Run skills transfer classes.*

For the development of Product A, the Product A development manager described the type of the organisational structure as functional and with the following departments participating in the development team.

> "*At the top, brand and marketing would be on there. Somebody from the technical support marketing...there is strategy on it as well, there is development manager, there is the test manager, we have the install and packaging in that team, we have somebody from user centred design, somebody from user technologies who does all the info-type stuff, we have somebody from our planning department, we have finance, somebody from service... I think I have covered them all*" ($I_{sofINPDMA}$).

The core NPD team for the development of product B consisted of the same departments as in the Product A. The type of organisation was:

> "*It is probably more functional than matrix. In the past we had all sorts of combination, but ultimately I think functional, I would say it works best*" ($I_{sofINPDMB}$).

6.5. Choosing The Two Products

The two products selected to investigate the involvement of product support in the NPD process were:

i. Asynchronous messaging software (Product A)
ii. Synchronous transaction processing software (Product B)

Both products are used by large enterprises, companies that want to integrate applications and businesses, and are financially critical to the firms that use them.

6.5.1. Product selection

6.5.1.1. Interviews with product support personnel

At the beginning of the case study the company's senior service planner and the development operations manager were asked to indicate an easy and a difficult to support product. They both indicated Product A as difficult to support compared to product B which was considered a relatively easier to support product.

6.5.1.2. Product review interview

When the final products were examined together with the senior service planner, several key differences in the designs were located during the product review interview ($PR_{sofICSM}$). Specifically, Product A is a more complex product in terms of the environment and the communication it uses. Communicating in several different environments, across various different platforms, makes more difficult to isolate and fix problems. Product B, on the other hand, has less interfaces and, as a product, is more concrete in service terms. Therefore, there is a standard procedure service engineers will have to follow to install fixes and upgrades.

6.5.2. Launch dates

Product A was launched in the market in 2002. As most of the software products of this type, it was based on the previous version with some major changes, as it was capable of "*operating on some additional platforms*" ($I_{sofINPDMA}$). Whilst, product B was launched in the market also in 2002, with its difference to its previous version being the addition of Java technology.

6.6. NPD Process Stages For A and B

6.6.1. Concept

In the first stage of the Software Company's NPD process (shown in Figure 18), the idea of the new product is developed and decisions about the strategy to be followed are made by the decision board. The product support department was not represented at this stage on the decision board.

> "*They are influencing. The reason I did not put them among the decision makers is that I don't think there is a support person that's on the decision board. It is most of them VPs. But that doesn't mean there is not enough pressure there*" ($I_{sofIStrategyM}$).

This fact was also supported by the Product A development manager, who explained the role of the development representatives in the decision board:

> "*Concept is a brand time, where... marketing, finance, project manager and our strategists get together basically and decide the theme of the release. From a peripheral side, we* [development] *actually get involved because we have to do a very finger in the air sizing or at least verify what our strategists think that we could size this out, and this is probably all our involvement in that stage. To say what sort of resources and profiles we have got, because they also come up with an intended delivery date, so we also got to check to see whether that it at all possible and ratify that*" ($I_{sof1NPDMA}$).

At this stage, for Product A, product support was not involved, as both the senior service planner and the Product A development manager think:

> "*During the concept phase, we actually don't get involved at all... The concept stage is a marketing requirement basically. So the marketing team will then come up with what it needs actually to be built into the product to meet the customer requirements. Once they have passed that requirement phase, they have permission to actually go and build the product*" ($I_{sof1CSM}$), "*At the concept stage, there was not involvement* [of product support] *at all*" ($I_{sof1NPDMA}$).

For product B, product support "*did exactly the same things as the Product A. Because the processes were the same, the stages etc*" ($I_{sof1CSM}$). The product B project manager added: "*For concept, as I say, I wouldn't say no involvement, they do get to hear what's going on, so they are an observer*" ($I_{sof1NPDMB}$). The product B development portfolio manager also agrees: "*I don't see much evidence of product support* [at the concept stage]. *There are guys from the service area who do get involved with some of the high-level decision-making, but they don't tend to be many of them. They are observers*" ($I_{sof1MarketingMB}$).

In an effort to find evidence to support the above views, the Timeline of the IPD project and the Serviceability Bucket documents of both products were examined. However, they showed no evidence of product support providing input at this stage.

The findings for this stage can be summarised in Figure 18.

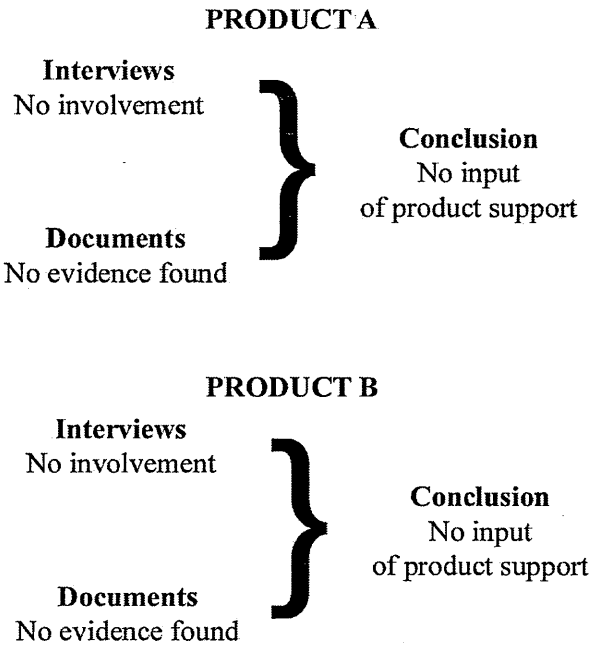

Figure 18: Findings of Concept stage

The managers interviewed agreed that product support was not actively involved in any decision making regarding both products. Document evidence supported their claims. Therefore, one might argue that the input of product support was non-existent at this early stage of the NPD process for both products.

6.6.2. Plan

In this stage, after the decision board has come up with the idea for the new product (business case), the development team is created with personnel from all relevant departments, as explained in section 6.4. This team will set the specifications (ability to trace, ability to dump, first failure data capture etc) for future products and will follow the new product through the development process till its launch in the marketplace.

As supported by the interviews, product support had some influence over the product specifications from the service perspective: "*I have influence over what is built into the product from a service perspective, because I can raise issues about the product, I can raise requirements during that phase*" ($I_{sofICSM}$), "*At the product specification, we actually have a serviceability bucket, which is basically very specific for what the service actually want. So I would say that they have some peripheral involvement and there has been some items we have put in plan because they asked us to put in plan*" ($I_{sofINPDMA}$). However, in this version of the Product A "*service hasn't come up as an important area, security did and so integrating* [with other products of our company]" ($I_{sofIMarketingMA}$).

In detail, product support created a document called 'Serviceability bucket' as a means to communicate all service requirements to the product development team. As the Product A development manager said the product support input was "*in fact, only the serviceability bucket that I know of*" ($I_{sofINPDMA}$). In this document, product support focused on "*Two of the real key things that must exist within a product: the ability to trace and the ability to dump. That, in conjunction with the first failure data capture, which is very important because you must ensure that a software can't progress too far*

past the problem before you take a snapshot of what happened when the problem occurred" ($I_{sofICSM}$).

In addition to these, the usability of the Product A was also assessed in the planning phase. "*Usability is actually assessed at the planning phase and we have a particular group which address the usability of the product. There are certain standards we have to meet and they actually make sure that they fit*" ($I_{sofICSM}$).

As the managers' interviews converge, one can conclude that product support had some influence over the overall requirements of Product A, however this was limited because of the focus of the company in other areas than support. For the product B, the project manager suggests a small change of the input of product support into the specifications through the serviceability reviews.

> "*It's generally through the serviceability reviews actually, 'cause that's where all the developers sort of present, first of all, what they think they are going to do, and second what they have done. And that's when service really start to get involved... So, out of the serviceability reviews they raise numerous and numerous of requirements of 'can you do more tracing here?', 'can you change these messages?' or 'expand this data field so that we can get some support information', they put lots of requirements*" ($I_{sofINPDMB}$)

The actions taken by support are focused on "*looking quite narrowly at the function of the product, and they are looking from the service point of view. So they are very effective at influencing what happens from a serviceability point of view*" ($I_{sofINPDMB}$). The changes required in product B were not major as "*the serviceability of the product was already there, it existed, but it had to be more specific to what the guys were doing, defining the problems and solving them*" ($I_{sofICSM}$). The product B development portfolio manager adds: "*The product B didn't have much in terms of new function, but we did a lot in terms of reliability, performance and availability*" ($I_{sofIMarketingMB}$). Similarly to the development of Product A, there were two managers in the development team that "*looked at the usability side of the product before we enter at the development phase, where it's too late to make high-level design changes*" ($I_{sofINPDMB}$).

Further support was looked up into the documents related to this stage for both products. The documents examined revealed no support targets of qualitative or quantitative nature. It seems that most of the requirements were communicated through discussions rather than a formal written process.

A summary of the findings for both products at this stage is show in Figure 19.

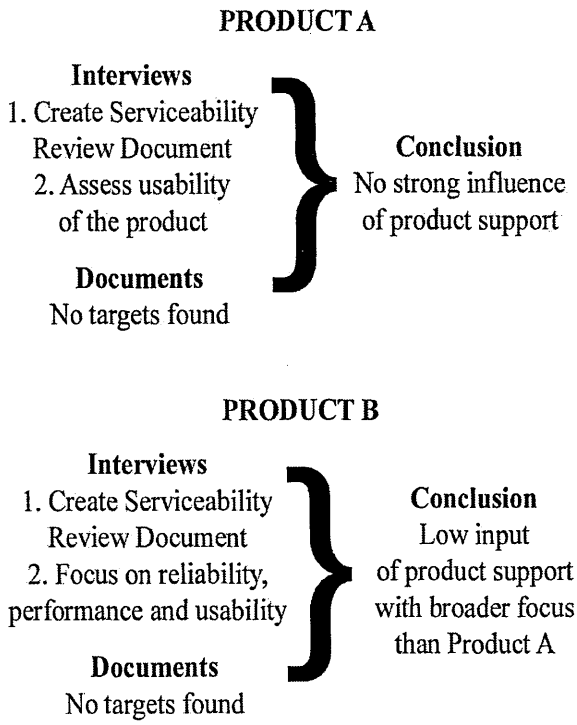

Figure 19: Findings of the Plan stage

On the overall, no design targets were found in the documents. The evidence from the interviews suggest a greater focus on support and in particular the reliability and usability elements of product B than in Product A. The comparison of data supports the view that in the Plan stage product support had a relatively small influence in both products, with product B having slightly more input than Product A.

6.6.3. Development

At this stage, the coding of the products is produced. From all interviews, it was obvious that product support was represented in the product development team by "*the service planner and also a team lead from the US service, so yes, they were there*" ($I_{sofINPDMA}$).

For Product A, the development manager requested the information provided by support, as she thought that "*there is a whole set of people who are part of the development and they need to understand what we are delivering, because we are not testers, we are not service people, we are developers as such, and for those people to say: 'I actually need to understand this, I need to do this', that's why I said that service had to approve every single DCR*" ($I_{sofINPDMA}$).

The input of support was focused on the items that were service specific. The Product A manager said: "*They will have opportunities to ensure that it is serviceable and then, as I said before, there are certain items that go in there purely for serviceability. But there aren't that many, because they don't show... their value is not that much to the customer, it is for the internal service organisation*" ($I_{sofIMarketingMA}$).

However, the overall involvement of support at this stage is limited. The development manager commented that coding is not part of the support responsibilities. "*Once we actually have agreed what we are going to deliver serviceability-wise, they don't actually get involved at all. It would be nice if they came and coded*" ($I_{sofINPDMA}$). The Product A manager added: "*They get involved with some of the design and*

development, where they can see flaws, where we are not providing them the ability to maintain the product. So that's where they will influence the decision-makers. On the whole, though, I would suggest that they provide information" ($I_{sof1MarketingMA}$).

The documentary evidence (which was mainly the minutes from meetings) for this stage of product development for Product A shows that product support offered verbal information to the development team but set no design goals.

The input of product support in the development phase of Product B is similar to the one above. Product support still "*probe technically about how things will work, so they question the developers on 'how this is going to work' or... again it is all with the view to support, but because in general the service people are very experienced people, experienced teams, they can steer development in the right direction. And in that discussion, the technical discussions, they are also obviously getting education for themselves, they are increasing their knowledge of the new function as well*" ($I_{sof1NPDMB}$).

However, actions of support personnel are not so influential overall, as they don't design the product themselves: "*What usually happens is that they design the product. They know what format it is going to take. I ensure that the serviceability exists within that design. So it runs in parallel, but it is not compressed. You can design a product without service. So I ensure that the service is there*" ($I_{sof1CSM}$). And how is this achieved? The senior service planner commented: "*I have influence over what is built into the product from a service perspective, because I can raise issues about the product, I can raise requirements during that phase. So if I see something about the product that I don't feel it is right from the perspective of 'we couldn't service that' or 'it will be difficult to service', we raise that and we raise that as an issue. 'I need more information on this' or 'we need to build this into the product to ensure that we can actually adequately maintain it'*" ($I_{sof1CSM}$).

Similarly to Product A, the documentary evidence for Product B shows that product support offered verbal information to the development team for the serviceability of the product but set no design goals. The documentary and interview evidence found for both products are shown in Figure 20.

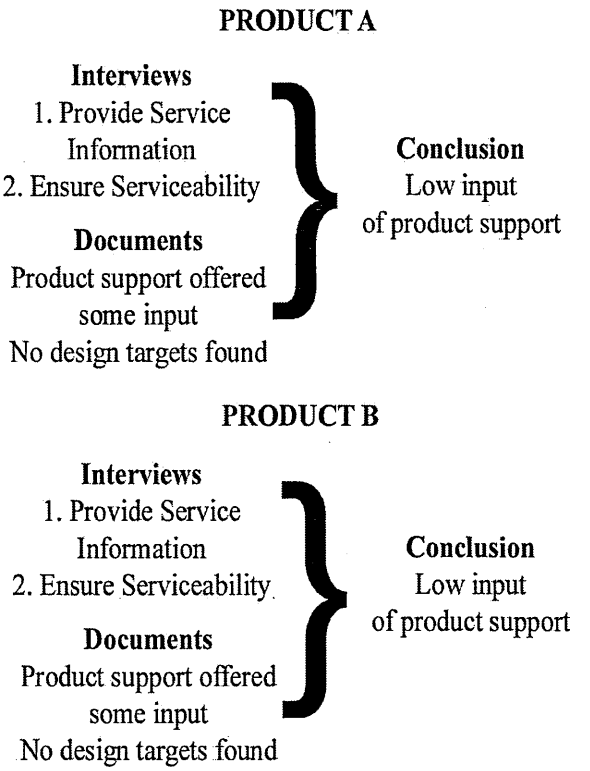

Figure 20: Findings of Development stage

Based on the evidence, the interviews and the available company documents, it would be fair to argue that there was some involvement of product support at the development stage of both products A and B, mainly focused on the items required by the service people. In that sense, product support involvement in the development stage was rather informal and had affected the product design in an implicit, indirect and tacit manner.

6.6.4. Testing

At this stage, the products of Software Company go through rigorous testing in an effort to identify potential problems and bugs before releasing them into the market. The testing could be separated into three different phases: Unit testing, System testing and Beta testing.

During the development of Product A, product support "*didn't have actually anything to do with unit test. It's pretty much functional... they had no involvement*" ($I_{sof1StrategyM}$). However, at this phase, a serviceability review is completed, as the development portfolio manager commented: "*The initial serviceability review happens well within unit testing, that sort of area*" ($I_{sof1MarketingMB}$). And he added: "*The senior technical manager, because of his in-depth knowledge and influence, experience with the customers, he runs the serviceability reviews, to ensure that the actions are taken before we enter the availability decision checkpoint*" ($I_{sof1MarketingMB}$). It is however noticeable that no manager involved at the development of Product A mentioned the serviceability review at the phase of unit testing and no evidence on documents was found that this actually happened, although it exists officially on the product development process.

The initial input of product support for Product A took place at the System testing. Both the development operations manager and the Product A development manager gave extensive comments on the input product support offers to the team:

> "*They are certainly involved in some of the early testing activities,* [they] *would do service testing as part of the system test*" ($I_{sofIStrategyM}$).

> "*They are not necessarily looking from a functionality aspect, although they do obviously because they have customer feedback and things, but they are looking at it from 'Is it going to be serviceable', making sure that we are doing things in that new functionality that would make it easily serviceable for them, they will float migration type issues and ensure that we will do those sorts of things and they make sure each of the areas understands what each piece of functionality will entail and what we need to do... We did have to do some proving to see what we put in actually worked and we did that within system tests. That was about two weeks worth of testing. And that again it was because of the serviceability bucket, it was an item that was in the serviceability bucket that we coded and we had to prove it worked... it is part of the system test, you would expect them to try and break the product and to test, part of their test plans would be to test error situations as well, to ensure that the right error codes are coming out*" ($I_{sofINPDMA}$).

All actions taken by product support at this phase, are basically based on another serviceability review that takes place during system testing: "*we came back some time at system test to actually check, you know, to run another review... once we have finished the code*" ($I_{sofIMarketingB}$).

During the Beta testing for Product A, product support was again involved: "*They are certainly involved in the beta tests. For betas, we try and use the service stream itself pretty much all the time*" ($I_{sofIStrategyM}$). What product support do is "*access to the system test and the unit tests and actually see the errors on the code, just to get a trend, so that they've got a number of tests, every area has to be completed, they know how many errors have occurred and know how to fix that part*" ($I_{sofICSM}$). In order to help the development team, they use several targets. Reliability is one of them: "*Reliability yes, because we stressed the products and there would be certain targets as we went that we would set at the stress team. Initially when they started, it does fall over slightly, we basically increase the load and the time of the load on the systems to a level that we would then feel that is acceptable. And we actually stress it so much that we actually break it, and we know that the customer wouldn't stress it that much*" ($I_{sofINPDMA}$). In addition to that, "*we do installation and migration testing, that's all part of the sub tests of the testing team. They do actually install tests, they do flavours of install tests, and they also do migration tests from the previous release to the next release*" ($I_{sofINPDMA}$).

The senior product planner commented on the targets used during testing: "*They know they have got a previous model. They know they have to be better or equal than that previous product... They know the targets should be errors per thousand lines of code. We put the expectations in the requirements and we say: 'this is what we need as far as the service is concerned. How many of these line items have you succeded to meet?'*

and I will put my evaluation.... at the end of the day you can actually see how close they are to that 0.3 errors per thousand lines to be expected in the field" ($I_{sof1CSM}$).

The testing of product B included the same phases described above. For unit and system testing, product support ran serviceability reviews, as happened during the process of Product A. "*What we do is we take the product and there is what we call the serviceability review. We put our requirements at the serviceability review and say what we would like to see for each particular section of the product: 'have we done this?', 'have we done this?'... We used The PD scorecard that we had done for the product. It is the Product Determination scorecard, which has a whole list of questions. We have a whole range of standard questions for this review. The product is marked against each section and comes out with a figure in the end. And if the figure is too low, we do have to start pushing to get serviceability in the product*" ($I_{sof1CSM}$). "*The initial serviceability review happens well within unit testing... and then we would come back some time at system test to actually check, you know, to run another review... So when we know what we are actually going to produce, the service guys would review and put forward their requirement and we will try and satisfy as much of that as we can, at least have an answer why are not doing it, as example because it costs too much or not enough time to implement, or we can follow up with current design change release, it comes after the product ship*" ($I_{sof1MarketingMB}$).

On beta testing, the service personnel "*have a lot of influence... they will decide how we will actually try to service, or how to service the beta product when it is actually in the field with the customers*" ($I_{sof1MarketingMB}$). And this is a major change on the process, comparing products A and B. The product B development portfolio manager continues: "[support] *did real testing with real end users on real code as part of the beta test. So we got customers in, not many, 2 or 3, and took them through it and they actually stood up and gave us this type of innovation. But that was a small piece of the product, it was a particular tool that we were doing in product B and then took it in the next version as it was. It wasn't for the whole product, it was only partial*" ($I_{sof1MarketingMB}$).

The targets used during the testing of the product for support purposes were the same as Product A. For the reliability, some of the targets were: "*we don't ship a product with any severity 2 defects, so that's a goal. Another goal would be, for example, we do some functional verification and we don't stop our system test, system phase of the testing, until we have run 80% of functional verification tests satisfactorily*" ($I_{sof1NPDMB}$). Other targets that were used during the testing stage were defect counting and number of errors per thousand lines: "*We use defect counting a lot. I mean really that's one of our fundamental quality measures. The number of defects raised in the whole of the release. And then the number of defects we've currently got open or waiting to be validated, to see whether the fix actually works*" ($I_{sof1NPDMB}$), "*By the number of errors that have been found at the end of the day you can actually see how close they are to that 0.3 errors per thousand lines to be expected in the field*" ($I_{sof1CSM}$).

The documents examined for this stage were the Serviceability Review document for Product B and the Product Determination Scorecard for both products. All documents included targets from product support and supported the view that product support provided significant input at this stage. The targets for Product A were: a) "*Better or equal than previous version*" ($D_{sof1PLD}$) and b) "*0.3 errors per thousand lines*" ($D_{sof1PLD}$). The targets for product B were: a) "*Better or equal than previous version*"

($D_{sofIPLD}$), b) "*0.3 errors per thousand lines*" ($D_{sofIPLD}$), c) "*No severity 2 defects*" (which means no really severe defects) ($D_{sofISRB}$) and d) "*Number of defects raised during testing*" ($D_{sofISRB}$). Findings for both products A and B can be summarised in the Figure 21.

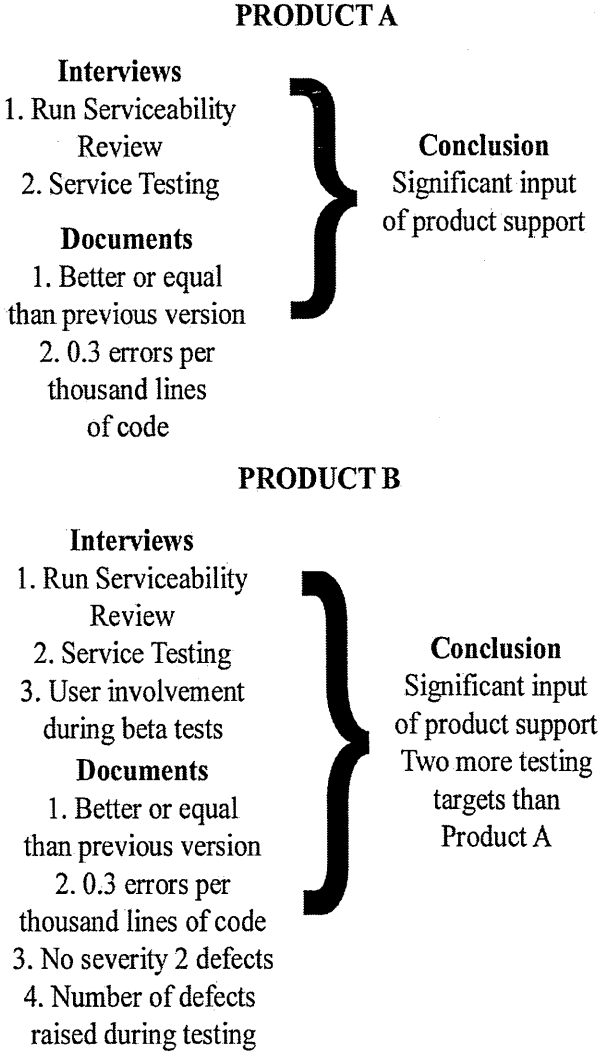

Figure 21: Findings of the Testing stage

Based on the views from the managers and the document evidence of product support involvement at this stage for both products, one could conclude that the input of product support was significant at this stage for both products. The major difference between products A and B was the involvement of customers during the beta testing, which gave the chance to the development team to test the product in real life situations, getting considerable input even though it was only for a specific part of product B.

At the end of the Testing phase, as part of the sign-off, the product support had to sign-off for the final designs of both products: "*At the end of the beta testing, once we have actually gone through system test, then, before they take ownership of it, they have to sign off as well*" ($I_{sofINPDMA}$). This is the sign-off to release the product into the field. The input of support is required as "*they are one of the decision-makers there, they can veto the shipment*" ($I_{sofIMarketingMB}$), "*they are definitely amongst the decision makers there, because they have to approve and concur with the checkpoints*" ($I_{sofINPDMB}$).

6.6.5. Launch

After the sign-offs of the final product coding, both products entered the Launch phase. In this stage the product designs are transformed into the physical products, accompanied with a package and documentation, and then launched in the market.

At launch, before any documentation gets into the packaging of the products, product support "*the support guys would be reviewers in that process... they also create additional materials, which are part of the online support systems, which are part of more complex things. They write things called red books, which is the 'how to' guides, which is more than just the product, they include installation, and they actually create these guides*" ($I_{sof1StrategyM}$).

In addition to the documentation, product support had to "*ensure diagnostic documentation is complete and available for use in the skills transfer class. Every single product that gets out of here I have to organise what we call a skills transfer, education course... it's the last thing I will do to ensure that everybody is educated on the product*" ($I_{sof1CSM}$).

After the release of both products, product support influenced the decision-making process as "*they played a significant part in that all the time, and in fact it is a regular part of the process. We have again, looking at what they have done in terms of influencing, whether they fit, we have a target to give the product support people logically development funds available, as part of the development cycle. So they can say 'the five things that we really need to do are these', and we will incorporate that into the next product plan*" ($I_{sof1StrategyM}$).

In the following section, a comparison of the two products on the involvement of the product support in the New Product Development process will be presented.

6.7. Summary Of Findings

The development of products A and B was based on similar product development processes. However, the involvement of product support in the product development processes of the two products varied slightly. Tables 29 and 30 illustrate the involvement of product support in the NPD process for products A and B respectively.

Product A

NPD Stages	Concept	Plan	Development	Testing	Launch
Timescale	12/2000	12/2001	03/2002	06/2002	10/2002
Product Support Actions	No involvement ($I_{sof1CSM}$) ($I_{sof1NPDMA}$)	Create serviceability review document Assess usability of the product ($I_{sof1CSM}$) ($I_{sof1NPDMA}$) ($I_{sof1MarketingMA}$)	Provide service information Ensure serviceability Set service goals ($I_{sof1CSM}$) ($I_{sof1NPDMA}$) ($I_{sof1MarketingMA}$)	Run serviceability review at least once on system test Service testing during beta test (includes installation and migration testing) ($I_{sof1CSM}$) ($I_{sof1NPDMA}$)	Sign-off final product coding Review documentation Organise skills transfer classes ($I_{sof1CSM}$) ($I_{sof1StrategyM}$)
Product Support Targets	None found	None found	None found	- Better or equal than previous model - 0.3 errors per thousand lines of code ($D_{sof1PLD}$)	None found

Table 29: Findings for Product A

One can see from Table 29 that the only service related targets set for the development of the Product A were dealing with the number of errors per thousand lines of code. No design goals were set for the product support elements; however the product support was involved in the design stage of the product development providing information to the team regarding service requirements. Product support really got involved at the testing phase, when they had to do the serviceability reviews and to sign-off the final product designs, just before the product entered the launch stage.

Product B

NPD Stages	Concept	Plan	Development	Testing	Launch
Timescale	12/1999	03/2001	07/2001	10/2001	01/2002
Product Support Actions	No involvement ($I_{sof1CSM}$) ($I_{sof1NPDMB}$) ($I_{sof1MarketingMB}$)	Create serviceability review document Focus on reliability, performance and usability ($I_{el1NPDMB}$) (I_{el1CSM})	Provide service information Ensure serviceability Set service goals ($I_{sof1CSM}$) ($I_{sof1NPDMB}$)	Run serviceability review at least once on system test Service testing during beta test (includes installation and migration testing) User involvement during beta tests ($I_{sof1CSM}$) ($I_{sof1NPDMB}$) ($I_{sof1StrategyM}$)	Sign-off final product coding Review documentation Organise skills transfer classes ($I_{sof1CSM}$) ($I_{sof1StrategyM}$)
Product Support Targets	None found	None found	None found	- Better or equal than previous model - 0.3 errors per thousand lines of code - No severity 2 defects - Number of defects that were raised during testing ($D_{sof1PLD}$) ($D_{sof1SRB}$)	None found

Table 30: Findings for product B

In the case of product B (Table 30), the involvement of product support in the product development process changed slightly. Although the product support provided the same type of information in the plan and the development phases, in the testing phase they added a couple more product support targets and they involved users who would beta tests in an effort to identify flaws and problems. In comparison with Product A, product B had marginally more input from product support in the Testing phase.

Table 31 highlights the main differences in the actions taken for the development of the two products.

Stage	**Differences in actions taken during the development of product B comparing to the product A**
Concept	No differences
Plan	Focus on reliability and performance (product B)
Development	No differences
Testing	User involvement during beta testing. Two more testing targets (No severity 2 defects, Number of defects that were raised during testing).
Launch	No differences

Table 31: Main differences between the two Software Company products

The reliability of both products was increased over their previous versions. Product B had increased reliability. Product B is easier to support as it has less interfaces and, as a product, is more concrete in service terms. It appears that the increased number of testing targets used in Product B and the focus on reliability and performance at the Plan stage resulted to a design that made Product B relatively easier to support.

CHAPTER 7. CASE STUDY – HEAVY EQUIPMENT COMPANY

7.1. Introduction

In chapter 7, the findings from the Heavy Equipment Company case study will be presented. The section starts with a description of the data sources used for the data collection phase, continues with a reference to the organisation of Heavy Equipment Company and the NPD process employed, and concludes with the overall comparison of the involvement of product support in the development of the two products.

7.2. Data Sources

The focus of the study is to investigate the involvement of product support in the NPD process of two products in Heavy Equipment Company. The methods employed for the data collection phase are:

- *Interviews*. The managers involved in the development of two products, one easy to support and one difficult to support, were selected for the interviews. The interviews contained questions regarding the involvement of product support in the NPD processes for the two products and issues they would be aware of because of their positions in the company. The managers' positions and the referencing system used in the paper is displayed in Table 32.

Interviews	Length	Reference
Manager of Current Products	2h	$I_{heav1NPDM}$
Service Manager	2h	$I_{heav1CSM}$
Marketing Manager	2h	$I_{heav1MarketingM}$
Manufacturing Factory Manager	2h	$I_{heav1ManufacturingM}$
Product B Development Portfolio Manager	1 1/2h	$I_{heav1StrategyM}$
Product Manager UK	1 1/2h	$I_{heav1MarketingUKM}$
Manager of Customer Support UK	1 1/2h	$I_{heav1CSUKM}$

Table 32: Interview sources in Heavy Equipment Company

- *Product Review Interview*. The product review was conducted with the help of the Manager of Customer Support UK (Table 33 for reference). This manager was fully aware of the support performance of the two products and responded to questions regarding the tasks and the relative difficulty of the tasks undertaken by the support personnel in each product.

Product Review Interview	Reference
Manager of Customer Support UK	$PR_{heav1CSM}$

Table 33: Product review source in Heavy Equipment Company

- *Company Documents*. Another source of evidence was the Master Document List (see Appendix 8), an instrument used to retrieve the documents required for the research, from the company's library and managers' files. The documents collected covered the NPD process, the product specifications, the reviews and some performance post-launch measures. The documentary sources collected are presented in Table 34.

Documents	Reference
Product Delivery Process Document	$D_{heav1PDPD}$
Organisation Structure Document	$D_{heav1OSD}$
Product Specification Document Product A	$D_{heav1PSDPA}$
Product Specification Document Product B	$D_{heav1PSDPB}$
Product A Manual	$D_{heav11PAM}$
Product B Manual	$D_{heav1PBM}$
Marketing Guide Product B	$D_{heav1MGPB}$

Table 34: Documentary Sources in Heavy Equipment Company

The referencing system used in the previous cases was also employed in this case. The system is presented in Tables 32, 33, and 34, showing both the source (i.e. interviews, product review, documents) and the reference code allocated to each particular source.

7.3. Company Organisation

Heavy Equipment Company is a leading heavy equipment company operating with an annual turnover of over £1bn a year. Their main products are tractors used for agricultural purposes in more than 150 countries worldwide. The company has 9000 employees worldwide and product development takes place mostly in Europe.

The overall organisation structure of the company is shown in Figure 22. In Heavy Equipment Company, the product support personnel report into marketing, as illustrated below.

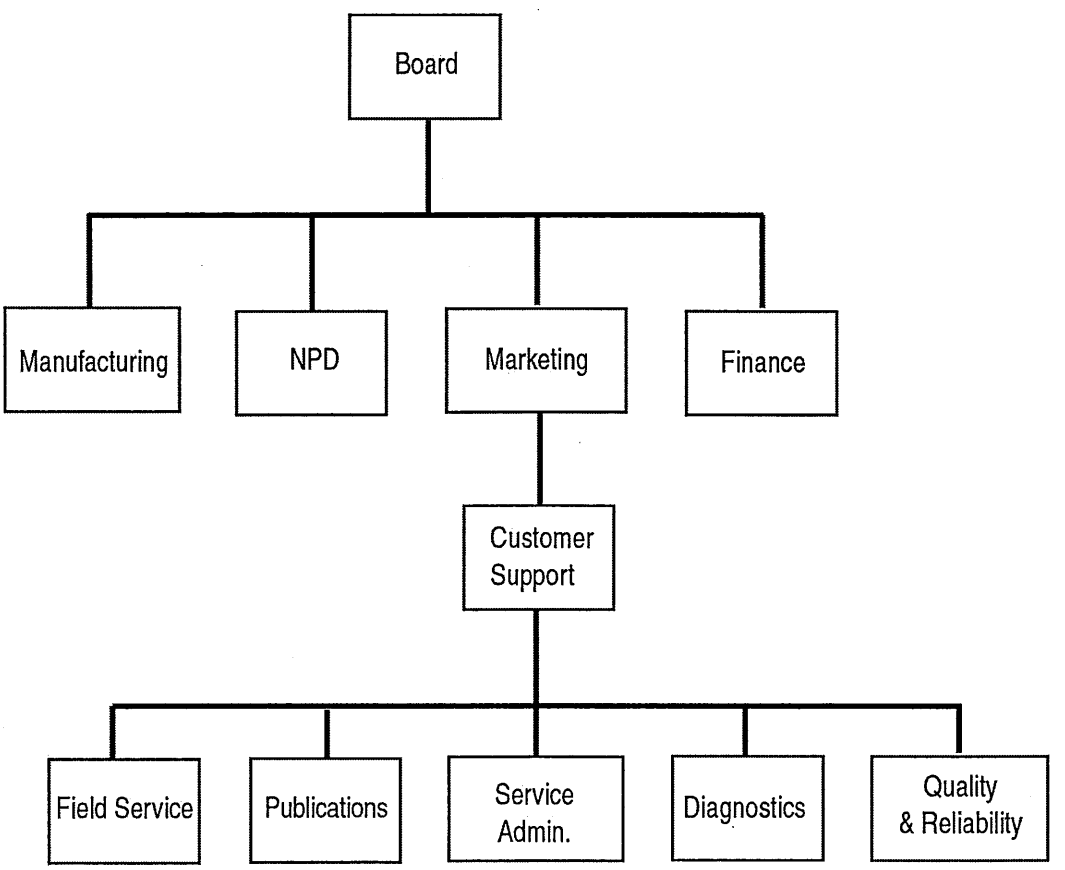

Figure 22: Position of customer support in Heavy Equipment Company's organisation ($D_{heav1OSD}$)

7.3.1. The role of product support in the company

Product support is directly represented at the top-level meetings in the Heavy Equipment Company by the Marketing Director. Many of the managers interviewed held the view that product support is an important process of the company: "*Customer support is one of our four core processes in this company. We have four core processes, which are: customer acquisition, order fulfilment, product development, and customer support*" ($I_{heav1CSM}$).

The manager of current products supports that product support "*is a very strong factor in our strategy. We have, we are extremely focused on product support, customer support we call it, not just product support, we support the customer with more than just the tractor. It is the parts, the training, the information he needs, we simply say he needs to do his job with our equipment and we need to make sure that he can do that with the maximum of comfort and convenience*" ($I_{heav1NPDM}$). However, almost all managers agreed that "*It's perhaps not a 'leading' part, but it is one of the four major processes we have*" ($I_{heav1ManufacturingM}$).

The responsibilities of product support include field service, publications, service administration, diagnostics and quality and reliability but not spare parts, which are dealt with from a separate unit.

The answer to the question of how important is product support to the customers of Heavy Equipment Company will be given in the next section.

7.3.2. Importance of product support

Providing quality product support to the customers of Heavy Equipment Company is "*vitally important. Because the product the customer buys from us is a tool for him. He buys that, or he rents it or he leases it, whatever, but mostly buys this product to do a job. So it is not a status symbol or anything like that, it's a tool that he wants to do his job with, he needs it to be productive*" ($I_{heav1NPDM}$). And this, in turn, "*is very strongly influencing the buying behaviour, because serviceability tends to go to some degree with reliability and durability, and the three together is what drives the second-hand value of the product. And the second-hand value is what drives the new equipment sales, if it is worth good money in three years time then it is economic good sense to buy a new one. So it is a very very important factor*" ($I_{heav1CSUKM}$).

During the product selection from potential customers, product support issues "*are probably the main differentiator between companies today is the support you provide after sales...There is probably less differentiation between products today than it was a few years ago. So then you look at what is the difference then. The difference is the overall service that the dealer provides to the customer. That would make the big difference*" ($I_{heav1MarketingUKM}$). The marketing manager agrees: "*I think the service and the product support is becoming one of the key issues already or will become one of the key issues for our customers in general. I see it more and more kind of product differentiator, our marketing argument, comparing to other competitors*" ($I_{heav1MarketingM}$).

More details of the importance of each of the product support elements for each of the products are presented in Table 35.

Elements of Product support*	Applicable	Case Study Data
Installation	Yes	
Training	Yes	"*Training is very important*" (manufacturing factory manager)
Usability	Yes	"*It is very important, especially when we talk about the ease of use*" (manufacturing factory manager)
Reliability	Yes	"*Reliability is the number one*" (manager of current products) "*Reliability is a very important element for sure*" (manufacturing factory manager)
Serviceability	Yes	"*Serviceability, from the customer's perspective, is a key factor*" (manager of current products)
Field Organisation	Yes	
Spare Parts	Yes	"*They are very demanding in terms of spare parts*" (service manager)
Documentation	Yes	"*Documentation is very important for our customers, especially when we introduce new components on the product*" (service manager)
Maintenance/ Preventative Maintenance	Yes	"*Very important because this is cost and time*" (manufacturing factory manager)
Repair	Yes	"*Speed of repair is really important for our customers*" (product manager UK)
Upgrades	Yes	"*Upgradeability is such a thing, I mean you have surprises. You think the world will break down at certain times if you don't provide it. Now you provide it, but you don't sell that many.*" (service manager) "*Upgrades are not so important*" (manager of current products)
Online Support	No	
Cost of Ownership	Yes	"*The most important element of all is the cost of ownership... because the cost of downtime is always very high, the customers put much attention to it, much more than in the automotive industry*" (marketing manager) "*They asked us to reduce the overall running costs of the tractor*" (product manager UK) "*Cost of ownership includes all, how much fuel you use, you need and service cost... this is why they buy our company's product*" (manufacturing factory manager)

Table 35: Product support elements and their importance to Software Company customers

*Based on Goffin (1998)

7.4 Company NPD Process

The stages of the product development process and the subsequent review meetings (i.e. the gates) in Heavy Equipment Company, for Product B, are illustrated in Figure 23. The process used for the development of Product A was fairly similar, having even similar names for the various stages, but not as well documented.

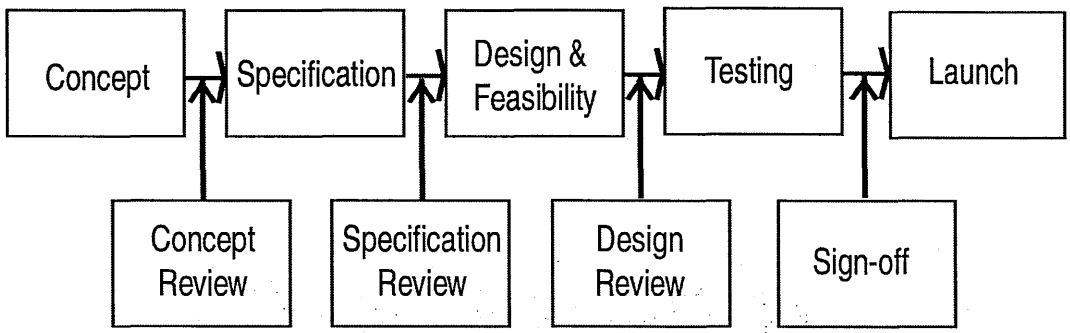

Figure 23: Product development process in Heavy Equipment Company ($D_{heavPDPD}$)

This data is retrieved from the company's Product Delivery Process (PDP) Document and describes accurately the process that was followed for the new products development. Five stages are included in this process:

- ***Concept:*** *Idea creation. Additional information on competitive products*
- ***Specification:*** *Specifications and marketing assessments.*
- ***Design and Feasibility:*** *Design creation and Manufacturing plan.*
- ***Testing:*** *Show that product meets specifications and that processes are capable.*
- ***Launch:*** *Measure project performance against key performance indicators. Identify outstanding marketing and support issues.*

For the development of Product A, the manager of current products described the type of organisation as a matrix organisation: "*it wasn't called matrix, but it was an engineering system, we always had systems. You could call it a matrix organisation, yes we had that, we may not have had so much, it may have been or it was a more closed shop engineering department*" ($I_{heav1NPDM}$). For Product B, they also used a matrix organisation: "*the organisation used is a matrix type organisation*" ($I_{heav1NPDM}$). A major difference between the two processes is that product support was not so much actively involved during the development process: "*Not to my knowledge, at least the importance to have this involvement in these early phases I think was not given in the same way as it is done in Product B*" ($I_{heav1MarketingM}$). For Product B, in the development team "*the whole organisation is represented. Marketing is in there, service is in there, parts support is in there, all those people are part of the development and they sign off it*" ($I_{heav1NPDM}$).

7.5. Choosing The Two Products

The two products selected to investigate the involvement of product support in the NPD process were two versions of the same product, a farming tractor:

i. Older version (Product A)
ii. Current version (Product B)

Both products are used by professional farmers and are financially critical to the customers that use them, as their income depends among all on their equipment.

7.5.1. Product selection

7.5.1.1. Interviews with product support personnel

At the beginning of the case study the company's customer support UK manager and the service manager were asked to indicate an easy and a difficult to support product. They both indicated Product A as difficult to support compared to Product B which was considered a relatively easier to support product.

7.5.1.2. Product review interview

When the final products were examined together with the service manager, several key differences in the designs were located during the product review interview ($PR_{heav1CSM}$). Two major design differences were identified: a) the chassis frame and b) the tilting of the cab.

> *"So if you want to work on the transmission of our Product A you take the cab off and then you split the tractor in half, if there is a point you need to access it to get through... What we have with Product B is a frame design which is not just for serviceability, it also has to do with the marketing because it carries more weight and creates a lightweight transfer and this kind of stuff...But also, the big thing that they did, they made the cab tilt. So for the really complex types of repair, this design of tractor is considerably better. And this whole idea of tilting the cab is purely for serviceability, there is no marketing need for it, there is no other functional need to have the cab tilt rather to lift off, doesn't make the production and assembly any easier, it is purely for service and repair. It probably adds cost, in fact, but it reduces cost of ownership, because if you have a major transmission repair you do it in half the time. So there is more reliability because the tractor has less downtime... the labour requirement to do that is half"* ($PR_{heav1CSM}$).

Other differences identified between the two products were the improved diagnostic systems of Product B, its adaptability to different tyre sets by the use of modular design, the improved reliability due to lifetime componentry and the extended service intervals from 250hrs of Product A to 500hrs of Product B.

7.5.2. Launch dates

Product A was launched in the market in 1988, after a 3-year development project. As the manager of current products said, *"we didn't add many features but we added some*

performance and we added some reliability" ($I_{heav1NPDM}$). Whilst, Product B was launched in the market in 2002, with its difference to its previous version being the new style in the design and some further improvements in the performance and the reliability.

7.6. NPD Process Stages For A and B

7.6.1. Concept

In the first stage of the Heavy Equipment Company's NPD process (shown in Figure ()), "you define the product – concept" ($I_{heav1MarketingUKM}$). The idea of the new product is developed and decisions about the strategy to be followed are made.

For Product A, product support did not have any involvement at this stage: "*No, no, at that time we were not influencing these all that much, I don't think so... we did not have any influence over the business plan at all*" ($I_{heav1CSM}$).

For Product B, product support "*had not so much involvement over the concept to be followed*" ($I_{heav1ManufacturingM}$). The service manager agrees: "*In phase 1, the input of product support was not to the extent of writing a strategy*" ($I_{heav1CSM}$).

In an effort to find evidence to support the above views, the Product Delivery Process document was examined but no evidence of product support involvement has been found for either products.

The findings for this stage can be summarised in Figure 24.

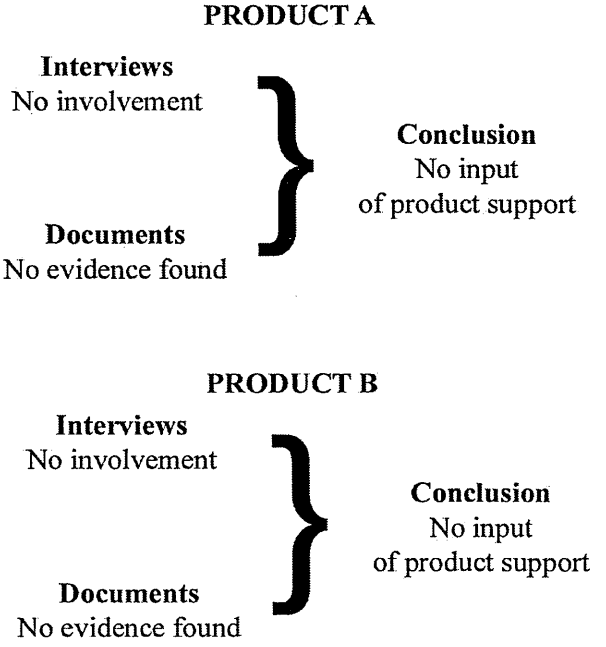

Figure 24: Findings of Concept stage

The design change (tilting cab) that noticed at the product review interview had been done with serviceability in mind but had not originated from the Product Support department of the company. It was not put forward as a concept from the support personnel. Instead it was an idea of the NPD managers. Therefore, the evidence of the new design does not affect the findings of the product support input in this stage. The managers interviewed agreed that product support was not actively involved in any

decision making regarding both products. No support on document evidence was found for their claims. Therefore, in the absence of written evidence, one might argue that the input of product support was non-existent at this early stage of the NPD process for both products.

7.6.2. Specifications

In this stage, the specifications for future products are set by the development team (reliability, power specifications etc).

As supported by the interviews, product support did not have some influence over the product specifications of Product A from the service perspective: "*I don't think we* [product support] *had input on the specifications either*" ($I_{heav1CSM}$). However, a problem noticed with the previous product was taken into account at this stage: "*A major wish from the support organisation at that time was to have a lifetime clutch... I was the service manager at that time, and had to pay a high warranty cost, because, right or wrong, clutches were wearing out and had to be replaced under warranty, and to an extend that was costing us a lot of money... we didn't satisfy the customer if his tractor has to be split in two. It was then decided to go to a wet clutch for the larger tractors*" ($I_{heav1NPDM}$).

Some of the key design parameters for Product A were: "*reliability, having Mean Time Between Maintenance set at 100hours, and lifetime componentry... also power increase, together with lift capacity increase*" ($I_{heav1NPDM}$). There was "*a lot of focus on the performance of the machine and...turning a bit tighter*" ($I_{heav1MarketingM}$). As one can see from the above statements, the only product support input on the specifications of Product A was the MTBM and the request for a lifetime clutch. The Product Specification Document of Product A supported the view of having the MTBM target, as it included the target of Mean Time Between Maintenance ($D_{heav1PSDPA}$).

The approach on Product B was more serviceability-wise. The product support input "*came at the specification as an input already out of lessons learned with the previous product, we wanted to have better serviceability from the customer's perspective, of cleaning the radiator for example, we have been criticised with our previous product. We knew we had to do that, it was part of the specification and also a major part of the specification was the diagnostics system... with Product B we introduced a formal connector, where the service organisation can plug-in their laptop and read out all those type of codes, error codes and service codes, and also, with Product B, we created the upgradeability of the electronics systems. That means that we can reprogram those tractors without removing parts. And that was very much an input from the service world*" ($I_{heav1NPDM}$).

The view that the product support input started at the Specifications stage was also supported by the service and the marketing managers: "*Our input came in the specs phase actually... it included reliability goals, serviceability issues, access to components, service intervals, it was a clear request voice that we would go to 500 hours engine, and it was also then implemented*" ($I_{heav1CSM}$). One of the actions taken at this stage was the increase of the Mean Time Between Maintenance: "*We established the MTBM at a very high level comparing to what we had in the past. To give you an example, from the customer support side, there was always a request for longer service intervals oil change intervals for instance and we are now approaching 500 hours, years ago we had a 100 hours*" ($I_{heav1MarketingM}$).

Other issues that were taken into account at this stage were the cost of ownership and the variants of the available models: "*The cost of ownership is a function of the machine investment, it has to do with fuel consumption and oil consumption considered with consumption of parts and reliability, and all of this is translated to the cost of ownership, so the cost of ownership along with many others is certainly in the product support plan, I think it is very much always a highlight, because the cost of downtime is always very high, the customers put much attention to it, much more than in the automotive industry*" ($I_{heav1MarketingM}$). "*Reduced cost of ownership and flexibility of what we could provide in the marketplace within that one design were also taken into account. By flexibility we mean the variants of the product to meet more and more market niches, by providing diverse transmission options*" ($I_{heav1MarketingUKM}$). The Product Specification Document for Product B that was examined for this stage of product development included two targets related to product support: a) the Mean Time Between Maintenance (MTBM) and b) the fuel consumption of Product B to be better than the previous model ($D_{heav1PSDPB}$).

A summary of the findings for both products at this stage is show in Figure 25.

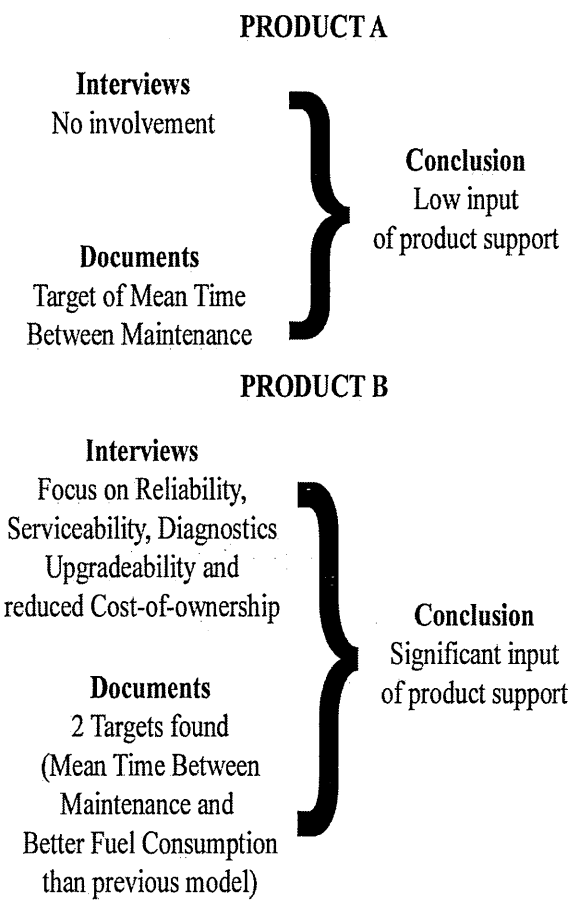

Figure 25: Findings of Specifications stage

On the overall, the evidence from both interviews and documents shows that the development team in Product B had more focus on product support than in Product A (see Figure 25). The number of design targets set for both products A and B at the Specifications stage is too small, compared to the number suggested by the literature and the performance data collected after launch. This comparison of data supports the view that in the Specification stage product support had significantly more input in

Product B, As it had one more design target than Product A and the team focused on various elements of product support (without quantifying them into design targets though) The issue then is whether these limited design targets were or not transformed into design goals in the Design & Feasibility stage. This will be discussed in the following section.

7.6.3. Design & Feasibility

At this stage, the design of the products is produced. The input of support here is determined by the level of interaction between the support personnel and the designers and engineers.

For Product A, product support did not influence the design at all. Both the manager of current products and the service manager agreed. "*Basically the engineers themselves, they knew what the goal was and they worked towards that*" ($I_{heav1NPDM}$), "*The design was done exclusively at engineering*" ($I_{heav1CSM}$). According to the service manager "*the target of Mean Time Between Maintenance set at the specifications stage was dealt with by the reliability department that existed at that time in the company under the umbrella of engineering and not the customer support*" ($I_{heav1CSM}$).

The Product Delivery Process document for Product A was examined to find support for the managers' comments. However, no input from the product support was found to exist at this stage of product development.

In Product B, product support "*worked with the designers... and yes, changes were made in the designs*" ($I_{heav1CSM}$). The manager of current products added: "*In the design, we would determine how we want to repair, how we want to remove components for example. And we'll have an input in that respect in the very early design stage, because we may influence, product support may influence whether a component is to be removed and exchanged or whether a component needs to be repaired. And therefore it influences the design... In the Product B, serviceability, better service, from the customer's perspective, was a key factor. We changed the whole engine enclosure to be able to service this product better. That was an input from them* [product support]" ($I_{heav1NPDM}$).

Part of the process followed in the development of Product B was the creation of the product support plan. "*We put the product support plan out in the design phase of the PDP*" ($I_{heav1CSM}$). This plan covered all issues regarding the training of the personnel, the provision of spare parts and all actions necessary for the successful product support of Product B. Apart from that, product support had "*the responsibility of evaluating the service abilities of the new product design. To achieve that, we used a CSI tool where we measure the previous version compared to the Product B*" ($I_{heav1CSM}$). This tool is a software application that helped the direct comparison of different service-oriented measures (for example, mean time between meaintenance) between the previous model and the current model that is being developed. Using this tool, the engineers were driven to changes in the product design in order to meet the specifications they set early in the product development process.

Similarly to Product A, the Product Delivery Process document for Product B was examined. It was found that product support constantly pushed the product designs in order to make it "*better than the previous version*" ($D_{heav1PDPD}$).

The documentary and interview evidence found for both products are shown in Figure 26.

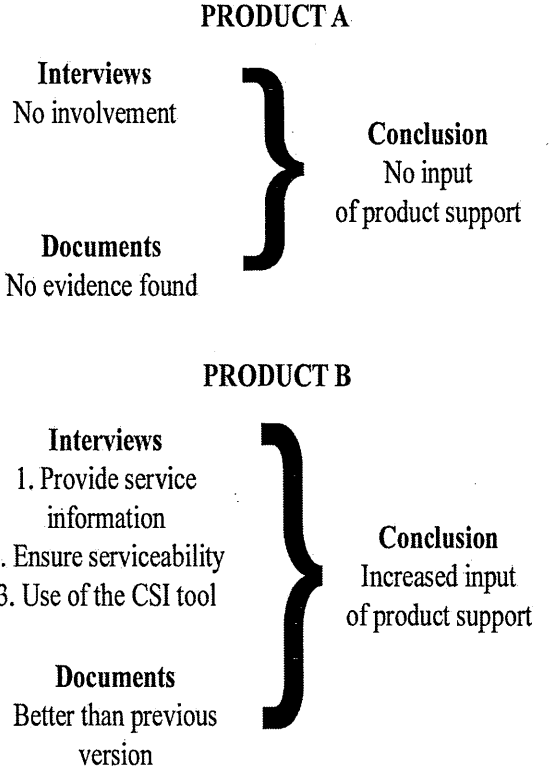

Figure 26: Findings of Design and Feasibility stage

Based on the evidence, one could argue that overall, the input provided by support at this stage was considerably higher in Product B than in Product A. The support personnel actively changed the product design in order to facilitate any service-related activities on the product in the market and the CSI tool used in the assessment at this stage enforced their efforts.

7.6.4. Testing

At this stage, pilot built machines (or else called durability test machines) are produced based on the designs of the products of Heavy Equipment Company and go through rigorous testing in an effort to identify potential problems before releasing them into the market and also to train the manufacturing personnel in the assembly lines. By this stage, at a parallel process to the development process "*we have done considerable tooling at this stage. Big changes are becoming now quite expensive*" ($I_{heav1MarketingUKM}$).

During the development of Product A, prototypes were created from the engineering department and "*they did test runs out in the fields with these tractors or put components on a test bench, like engines, transmissions or whatever, this is clear, to prove the reliability of these components*" ($I_{heav1ManufacturingM}$). The focus was on "*the design, more the design, more the feasibility and the reliability of the design*" ($I_{heav1NPDM}$) and it was managed by the "*Product Testing and Evaluation (PT&E) at the time, which is a department of engineering*" ($I_{heav1NPDM}$). This department was responsible for evaluating the product design at this stage.

From the product support perspective, the service organisation at this stage was mainly responsible for "*documentation was the prime job of the customer support*" ($I_{heav1NPDM}$). In addition, "*there was certainly some input from customer support already at that*

time, information, warranty data... their experience with previous products, it's always been put in there... they certainly played their role there, there have been at least looked at" ($I_{heav1CSM}$).

The only targets found in the documents that were service related and that the pilot built machines were tested against were reliability targets like Mean Time Between Maintenance or Mean Time Between Failures for the clutch of the tractor, which by design "*was not a lifetime component, if you have a dry clutch you have a wear sort of speak... and we needed to benchmark ourselves against the competition*" ($I_{heav1NPDM}$). The targets set at the specifications stage were again used here and "*they were eventually met, after some small design changes... remember that at the time, we were very good compared to our competition, but we were not leading the tractor segment, because we did not have the wet clutch to all of our tractors, a lifetime component, and we had to really increase the MTBF by other means... At that time we would say, it depends on the tractor, MTBF goals would be about 300 hours and that's what we wanted to achieve and we worked towards that by addressing the components and the items that were not living up to the expectation*" ($I_{heav1NPDM}$).

In Product B, the testing process had some substantial changes. The manager of current products describes: "*At the Product B, very early down the line brought in customers and showed customers from around the world where we were going, at the prototype stage, very early. We had prototype mock-ups, and showed the mock-ups and showed the designs of the mock-ups and what we were going to do and had their feedback purposefully. That is part of the development process, the PDP process calls for that*" ($I_{heav1NPDM}$).

In addition to a demonstration of the prototypes, customers also had the chance of a test drive of the durability built machines. "*About 30 or 40 of our durability tractors for a new product launch were running outside in the field, because we were trying to prove the MTBF, all this kind of stuff, to really ensure the reliability. So, we met drivers and in some cases farmers were doing that, and engineering hired special drivers for such occasions... And they gave us recommendations on what to change prior to the launch of the product*" ($I_{heav1ManufacturingM}$). This view was also supported by the product manager UK: "*After the durability built, we basically then had pilot built machines and it was at the end of the durability built, usually just as the very first pilot machines were built, we did another customer focus group. And this was really for product confirmation. We did not expect to this one to have any big surprises. If we had, we would have really messed up badly. Because it was really expensive then to make big changes to the product. We wouldn't make any changes at that stage, or we would delay the introduction or something because they didn't like it or it was not right, but we did not expect at that stage to get the big things wrong*" ($I_{heav1MarketingUKM}$).

Apart from the involvement of customers, one can observe actual involvement of product support at this stage. "*I think that one of their departments is the Reliability department or Field Services. And from this side, they gave input into the product engineering. So they used the prototypes and gave input on what they have found*" ($I_{heav1ManufacturingM}$). Product support personnel tried to identify potential support issues using the prototypes: "*For example, we are really opening the hood to see whether we have easy access to the filter or such kind of things. And this is later on, where the customer saves time and therefore money*" ($I_{heav1ManufacturingM}$).

And what happened when problems were found? The manager of current products comments: "*We actually had certain designs that were not accepted; we had to make changes because* [product support] *couldn't have access the way they wanted*" ($I_{heav1NPDM}$). And he added: "*We had some access issues, but we always have access issues with those complex products, we made some changes. For example, we had difficult access to our transmission oil, more difficult than the previous version, and there was really no way around that. But we found a way; we modified a filter for access over tools so that for the customer the problem is solved. That was an input that came from the service organisation*" ($I_{heav1NPDM}$).

Product support personnel also had to produce the documentation for the customers. It included "*operator manuals and the maintenance log, that's the two things that go to the customer. If the customer decides to install and implement an attachment after he bought the tractor himself, he would then get instruction with that attachment. But usually also those attachments would also be attached by dealers*" ($I_{heav1CSM}$).

Two targets for product support were identified in the documents examined (Product Specification Document Product B) for this stage of the development of Product B. The Mean Time Between Maintenance, which was set at 500 hours, and the Better Fuel Consumption than the previous model.

The following figure (Figure 27) summarises the findings for this stage of product development for both products.

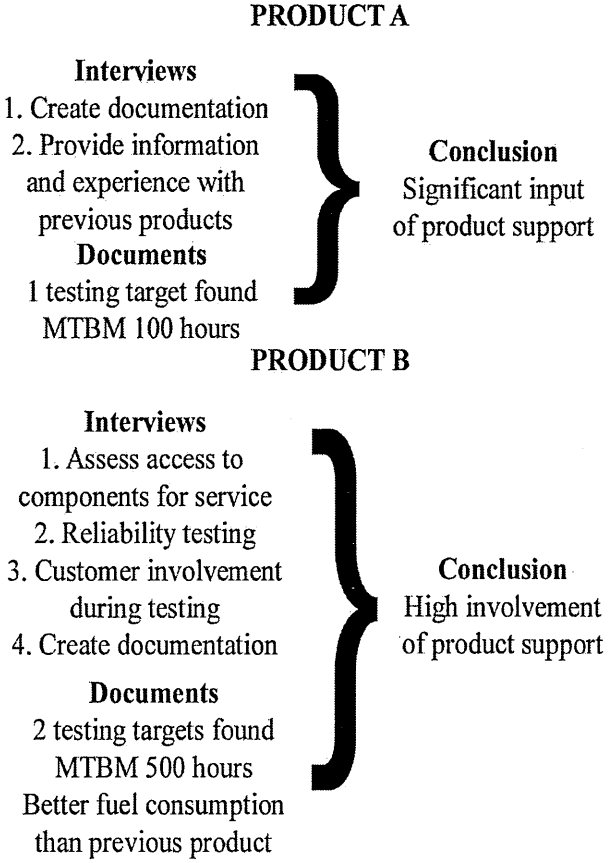

Figure 27: Findings of Testing stage

Based on the views from the managers on product support involvement at this stage for both products, one could conclude that the input of product support was significantly higher for Product B than for Product A. Two major differences were:

a) The involvement of customers who tested durability built machines of Product B, and gave the development team the opportunity to test the product in real life situations, getting considerable input and
b) The testing of the prototypes of Product B by the product support personnel with the serviceability issues in mind.

The design changes made prove that the company did not take lightly the product support requests and that this input was really important for the success of the product in the marketplace.

At the end of the Testing phase, as part of the sign-off, the product support had to sign-off for the final designs of both products before production: "*They have to approve the decision before the start of production*" ($I_{heav1ManufacturingM}$). The input of support is required as "*we cannot start the production without having the approval of support, they are one of the decision makers there*" ($I_{heav1MarketingM}$).

7.6.5. Launch

When everything else is in place, the product will get the final sign-off and will enter the Launch phase. In this stage the product designs are transformed into the physical products, accompanied with a package and documentation, and then launched in the market. "*And the main things that have to be in place are the operators manuals, technical manuals and a lot of the support information has to be available before we would sign it off, spare parts and that sort of thing, although it has to be happening. Production really happens two months before it gets to the field. So the day it is signed off doesn't mean our side depot here is bursting with parts, because we don't actually need them at that stage. But basically, all the parts have to be ordered and they are being fulfilled at that time, normally that would happen to the source depots at the factory*" ($I_{heav1MarketingUKM}$).

There is also a continuous improvement process that will then feed into the development of the next version of products. After the release of both products A and B, the responsibility is "*handed over to usually another group of engineers, who look after the current product in the field and then their main task is the problem resolution. These are not developing products; they are resolving field problems in maintaining the current product. And also developing the current product as well, intermediate upgrades like new bits and pieces. If they* [product support] *see something they could do to a product that will severely affect the ability to support it yeah, it will come up as a subject*" ($I_{heav1MarketingUKM}$).

In the following section, a comparison of the two products on the involvement of the product support in the New Product Development process will be presented.

7.7. Summary Of Findings

The development of products A and B was based on similar product development processes. However, the involvement of product support in the product development processes of the two products varied. Tables 36 and 37 illustrate the involvement of product support in the NPD process for products A and B respectively.

Product A

NPD Stages	Concept	Specification	Design & Feasibility	Testing	Launch
Timescale	1985	1986	1986	1988	End 1988
Product Support Actions	No involvement ($I_{heav1CSM}$) ($I_{heav1NPDM}$)	No involvement ($I_{heav1CSM}$) ($I_{heav1NPDM}$) ($I_{heav1MarketingUKM}$)	No involvement ($I_{heav1CSM}$) ($I_{heav1NPDM}$) ($I_{heav1MarketingM}$)	Create documentation Provide information and experience with previous products ($I_{heav1CSM}$) ($I_{heav1NPDM}$) ($I_{heav1ManufacturingM}$)	Sign-off final product design Organise field service ($I_{heav1CSM}$)
Product Support Targets	None found	Mean Time Between Maintenance ($D_{heav1PSDPA}$)	None found	MTBM 100hrs ($I_{heav1CSM}$) ($D_{heav1PSDPA}$)	None found

Table 36: Findings for Product A

One can see from Table 36 that the only service related targets set for the development of the Product A were dealing with the mean time between maintenance or else the service intervals. No design goals were set for the product support elements, however the product support was involved in the testing stage of the product development providing information to the team regarding service requirements and experience with existing products in the field. Product support really got involved at the testing phase, when they had to create the documentation and to sign-off the final product designs, just before the product entered the launch stage.

Product B

NPD Stages	Concept	Specification	Design & Feasibility	Testing	Launch
Timescale	1999	2000	2000	2001	2002
Product Support Actions	No involvement ($I_{heav1CSM}$) ($I_{heav1ManufacturingM}$)	Focus on reliability, serviceability, diagnostics, upgradeability and reduced cost of ownership ($I_{heav1NPDM}$) ($I_{heav1CSM}$) ($I_{heav1MarketingM}$)	Provide service information Ensure serviceability Use of CSI system ($I_{heav1NPDM}$) ($I_{heav1CSM}$)	Testing to assess the access to components for service Reliability testing Customer involvement during field testing Create the documentation ($I_{heav1NPDM}$) ($I_{heav1CSM}$)	Sign-off final product design Organise field service ($I_{heav1CSM}$)
Product Support Targets	None found	Mean Time Between Maintenance Better fuel consumption than previous version ($D_{heav1PSDPB}$)	Better than previous version ($D_{heav1PDPD}$)	- MTBM 500hrs - Better fuel consumption than previous version ($I_{heav1CSM}$) ($D_{heav1PSDPB}$)	None found

Table 37: Findings for Product B

Table 37 shows that, in the case of Product B, the involvement of product support in the product development process changed slightly. Although the product support provided the same type of information in the plan and the development phases, in the testing phase they added a couple more product support targets and they involved users who would beta tests in an effort to identify flaws and problems. In comparison with Product A, Product B had marginally more input from product support in the Testing phase.

Table 38 highlights the main differences in the actions taken for the development of the two products.

Stage	**Differences in actions taken during the development of product B comparing to the product A**
Concept	No differences
Specifications	Focus on reliability, serviceability, diagnostics, upgradeability and reduced cost of ownership (product B)
Design & Feasibility	Provide information, Ensure serviceability, Use of CSI system (product B)
Testing	Service testing, customer involvement during field tests, target for better fuel consumption than previous product (product B)
Launch	No differences

Table 38: Main differences between the two Heavy Equipment Company products

Product B was faster to service, lower fuel consumption and had increased reliability over the Product A. By consequence, it was easier to support and had a lower cost of ownership. It appears that the higher involvement of product support in the NPD process, especially in the Testing stage (i.e. extensive testing of the product in the company's labs and in the field), resulted to changes over the design of Product B, which made it easier to support and more competitive in the marketplace through the lower cost of ownership.

CHAPTER 8. CROSS-CASE ANALYSIS

8.1. Introduction

In this chapter, the results from the four cases, already presented in the previous chapters, will be analysed in a cross-case manner. In order to make a valid analysis of the differences between the processes of the case companies, the element of time was taken into account. This was considered necessary as a wide variation in the launch dates was spotted. As shown in the table below (Table 39), the launch dates of the difficult to support products ranged from 1988 to 2002. No such variation was observed for the easy to support products. Three (3) out of the four (4) products were launched in 2002 and one in 1999 (see Table 39).

Companies	Automotive Company	Electronics Company	Software Company	Heavy Equipment Company
Product A (difficult)	2000	1994	2002	1988
Product B (easy)	2002	1999	2002	2002

Table 39: Launch dates of the products investigated

The findings of this study are based on the comparison of two products per company. The products of the Automotive Company, the pilot case study, were a professional vehicle and a retail vehicle. As noted in Chapter 4, the nature of the two products makes them not easily comparable. However, as some companies do have fleets of some of retail vehicles (for example, the car rental companies), these companies could be treated as business customers and the retail vehicle as a capital goods product. In the Electronics Company, the two products were two different versions of an inkjet printer, an older and a more recent one. Similarly, the products selected for the Heavy Equipment Company were two versions of the same faming tractor. The two products selected for the Software Company were an asynchronous messaging software and a synchronous transaction processing software. Both products have similarities in terms of product development effort and importance to the customers, and therefore are comparable for the purposes of this study.

Before making a comparison of the product support involvement between the companies, an important note has to be made. Product support was found to be important to the customers of all companies, according to the managers and, in some cases, the customers interviewed. It would be therefore interesting to see how companies in different sectors tried to improve the supportability of their products through the development process. A generic model of a new product development process will be employed (Ulrich and Eppinger, 2000), as not all companies employ the same NPD model. This generic model includes the following 6 stages:

a) Planning
b) Concept Development
c) System-level Design
d) Detail Design
e) Testing and Refinement and
f) Production Ramp-up.

For each of the above stages, the findings of each case will be presented and a comparison of all companies will be made in an effort to further analyse the findings of this study.

8.2. Planning

The product planning includes the decisions about the product mix, prioritisation of the different projects, allocation of the resources and selection of the appropriate technology. The decisions to be made at this stage are about the product portfolio opportunities that will be pursued, the timing and sequence of the product development projects and the technologies that will be employed in the planned products.

Most of the above decisions are related to strategy and perhaps marketing. Thus, one would expect product support managers not to participate at this phase of product development. The findings from each of the cases, shown in Table 40, support this expectation, as no one from product support was involved at this stage of product development. The level of involvement in each case was determined by comparing the data from both the interviews with the managers and the documentation that was related to this particular stage. No contradictions were found between these sources.

Companies	Automotive Company	Electronics Company	Software Company	Heavy Equipment Company
Product A (difficult)	No involvement	No involvement	No involvement	No involvement
Product B (easy)	No involvement	No involvement	No involvement	No involvement

Table 40: Product support input at planning stage

8.3. Concept Development

At the concept development stage, the product is specified (physical configuration) and the firm selects the extended product-service offering for the lifecycle of the product (Gu and Sosale, 1999). The activities of the concept development stage include: the selection of the technological working principles of the product; the choice of functional elements, features and performance targets in order to best meet customer needs; and a choice of architectural approach. The choice of the architectural approach has implications for the effectiveness of approaches to the three development stages following concept development.

The findings from the case studies for this stage of product development are summarised in Table 41:

Companies		Automotive Company	Electronics Company	Software Company	Heavy Equipment Company
Product A (difficult)	**Actions**	Product and Service Information	Historical information for products in the field	No involvement	No involvement
	Document input	Input to Brand Positioning Document	None found	None found	None found
Product B (easy)	**Actions**	Product and service information Create Service Strategy (with individual strategies for diagnostics, repair, service, spare parts)	Historical information for products in the field	No involvement	No involvement
	Document input	Input to competitor performance document Service strategy	None found	None found	None found

Table 41: Product support input at concept development stage

At this table, one can observe that product support still has no involvement at the Heavy Equipment Company and the Software Company companies. In Electronics Company, the input of the support personnel was limited to the provision of historical information about the products already in the field. In Automotive company, however, the input of support gradually increased from providing product and service information for Product A to creating a documented service strategy to be followed for Product B, which included strategies for various aspects of product support, such as diagnostics, repair, service and spare parts.

8.4. System-level Design

The system-level design stage includes the development of the product architecture and the assignment of component development tasks to the development team. The focus of this stage is to carefully define component interfaces, specifying the associated standards and protocols. Performance targets and acceptance criteria are set for each component or integrated subsystem. These subsystems are frequently assigned to multi-

disciplinary teams who will share the responsibility for designing the components that make up the subsystem. The findings of all case studies regarding this stage are shown in Table 42.

Companies		Automotive Company	Electronics Company	Software Company	Heavy Equipment Company
Product A (difficult)	**Actions**	Set Service Targets	Set Service Goals	Create serviceability review document Assess Usability of the product	No Involvement
	Targets	Reliability Maintenance Cost of Ownership	Service Intervals Serviceable Items MTBF Product Lifetime	Usability	Maintenance Intervals
Product B (easy)	**Actions**	Set Service Targets	Set Service Goals Request for a more user-friendly product	Create serviceability review document Focus on reliability, performance and usability of the product	Focus on reliability, serviceability, diagnostics, upgradeability and reduced cost of ownership
	Targets	Maintenance Repair Usability Upgrades Cost of Ownership	Service Intervals Serviceable Items Usability Reliability Serviceability	Reliability Usability	Maintenance Intervals Better fuel consumption than previous version

Table 42: Product support input at system-level design stage

In Automotive company, product support set service targets for both products A and B, with a greater input in Product B in terms of the amount of targets. A similar finding was observed in both the Electronics and the Heavy Equipment Company cases, where more targets of product support were found to be set in Product B than Product A. In Product B in Electronics Company, an additional input from the product support side was the request for a more user-friendly product, and that was translated into a usability target to be set as specification for the new product. In Product B in the Heavy Equipment Company case, the focus on the reduction of the cost-of-ownership was translated into a better than previous fuel consumption specification.

In the Software Company case, product support had some input. The only specification found for Product A was the usability target. The input of support was increased in Product B, focusing on the reliability, the performance and the usability targets of the product that was developing.

8.5. Detail Design

The detail design stage is primarily concerned with component design, testing and production process planning. The management of the detail design consists of monitoring the progress of each individual component or subsystem design activity relative to the component performance targets and interface specifications. Whether the components meet their performance targets depends on their interaction and not on whether they meet some pre-specified criteria, especially when these components are part of a larger, integral subsystem of the product.

The findings from the cases regarding this stage of product development for all companies are presented in Table 43.

Companies		Automotive Company	Electronics Company	Software Company	Heavy Equipment Company
Product A (difficult)	**Actions**	Design Suggestions Monitor the product development	No Involvement	Provide service information Ensure serviceability Use of service goals set at previous stage	No Involvement
	Targets	None found	None found	None found	None found
Product B (easy)	**Actions**	Design Suggestions Monitor the product development Influence changes in the designs	No Involvement	Provide service information Ensure serviceability Use of service goals set at previous stage	Provide service information Ensure serviceability Use of CSI system
	Targets	Design targets for support (incl. cost of service and cost of repair goals) Serviceability and damageability tool (1250 items to check)	None found	None found	None found

Table 43: Product support input at detail design stage

In Electronics Company product support had no involvement at this stage. In Heavy Equipment Company, product support was not involved in Product A, however this was changed in Product B. They managed to provide service information to the designers and tried to ensure the serviceability of the product through the use of a documented system. In Automotive Company, product support went a step further in Product B, were they had set design goals for the engineers in terms of support. The company though that seems to have most influence from product support at this stage is the Software Company. In that company, product support, in addition to providing

information to the design teams, they had set service goals for the designers regarding the usability of Product A and the reliability, performance and usability of Product B. The targets found were the same as the ones identified in the previous stage

A significant difference observed in the Software Company from the other cases is that product support had set design goals for both products instead for only the easy to support product. In Automotive Company, design goals were set at the development of Product B but not of Product A. However, this last case has an important finding regarding the number of items checked at the detail design stage. In an effort to cover most of the support aspects of their Product B, the Automotive Company used a tool that included more than 1250 serviceability items to check.

8.6. Testing and Refinement

The product testing and refinement stage involves assembling and testing prototypes and implementing any required changes to the component designs. The tests are intended to detect unanticipated interactions among the components, and the changes that need to be made to the product design are entirely depended on the architecture chosen for the product.

One important finding is that, similarly to the detail design stage, product support was involved in all companies for at least signing-off the product design before launch. All actions and targets found for each case are shown in Table 44.

Companies		Automotive Company	Electronics Company	Software Company	Heavy Equipment Company
Product A (difficult)	**Actions**	Conduct reviews on prototypes Conduct field tests Sign-off the final designs Create customer support plan	Involved just before launch for the sign-off of the final product designs	Run serviceability review at least once on system test Service testing during beta test (includes installation and migration tests) Sign-off final product coding	Create documentation Provide information and experience with previous products Sign-off final product design
	Targets	None found	None found	Better or equal than previous model 0.3 errors per thousand lines of code	Maintenance Intervals: 100hrs
Product B (easy)	**Actions**	Conduct Reviews on Prototypes based on serviceability tool Conduct Field tests based on serviceability tool Sign-off the final designs Create Customer Support Plan	Extensive testing Influenced changes on the product designs Sign-off the final product designs	Run serviceability review at least once on system test Service testing during beta test (includes installation and migration testing) User involvement during beta tests Sign-off final product coding	Testing to assess the access to components for service Reliability testing Customer involvement during field testing Create the documentation Sign-off final product design
	Targets	1250 service items list	None found	Better or equal than previous model 0.3 errors per thousand lines of code No severity 2 defects Number of defects raised during testing	Maintenance Intervals: 500hrs Better fuel consumption than previous version

Table 44: Product support input at testing and refinement stage

The least input of product support was found in Product A of the Electronics Company, where product support was involved just before launch for the sign-off of the product designs. In Product B, on the other hand, product support did extensive testing of the prototypes and forced changes in the design of the product. In the Automotive Company case, product support conducted reviews and field teats on the products. They also used the serviceability tool of 1250 items as a basis for the evaluation of Product B.

In Product A of the Heavy Equipment Company, product support had the responsibility for documentation and provision of service information and they had to sign-off the designs. The only target found here was the Maintenance Interval. If one compares this input to the input provided during the development of the Product A of the Software Company, where extensive testing was made using targets of the type better-or-equal than previous product, one can see that there was still a way to go for the Heavy Equipment Company. This changed in Product B, as extensive testing was done with regards to service in both companies, and numerous targets were in place for the evaluation of the serviceability of the Product B. A noticeable difference to the other two companies (Automotive and Electronics Company) was the involvement of customers at this stage, something that may have helped identify at least some usability problems of the products.

8.7. Production Ramp-up

The last stage of the product development process refers to the decisions related to the production and the product launch to the marketplace. The product is manufactured using the intended production system. The workforce is trained and deals with any remaining problems in the production process.

Actions taken by product support at all companies at this stage are shown in the following table:

Companies	Automotive Company	Electronics Company	Software Company	Heavy Equipment Company
Product A (difficult)	Prepare the after-sales organisation and the spare parts	Organise the after-sales organisation and deal with field problems	Review documentation Organise skills transfer classes	Organise field service
Product B (easy)	Prepare the after-sales organisation and the spare parts	Organise the after-sales organisation and deal with field problems	Review documentation Organise skills transfer classes	Organise field service

Table 45: Product support input at production ramp-up stage

Across almost all companies product support had to prepare the after-sales organisation in the field, including the spare parts provision (see Table 45). In Software Company, at this stage, support reviewed the documentation, an input that was taken earlier at all other companies. Support also organised the skills transfer class in order to train the field personnel and the service managers on the two products.

8.8. Level of Involvement

In order to reduce the amount of data presented to the reader, the amount of product support involvement in the NPD processes will be summarised in four levels: no involvement, low, medium and high. The characteristics of the product support involvement for each of these levels are presented in Table 46.

Level of Product support Involvement	Characteristics
No Involvement	No involvement in the NPD team No input to NPD documents
Low	Provision of information to the NPD team Minor input to NPD documents
Medium	Active role in the NPD team but not influence over the product design - Set overall targets (but not design goals) - Conduct reviews/tests to identify major problems without serviceability tools Major input to NPD documents
High	Active role in the NPD team Influence product design changes - Set design goals - Use serviceability tools to evaluate product designs - Conduct reviews/tests with serviceability tools - Prepare the service organisation for launch (e.g. training, special tools, spare parts, etc.) Major input to NPD documents

Table 46: Level of product support involvement in the NPD process

Based on Table 46 and on the tables of the previous sections of this chapter, the findings of the involvement of product support in the NPD process across all companies could be illustrated as shown in Table 47.

	Stage of NPD					
Case	**Planning**	**Concept Development**	**System-level Design**	**Detail Design**	**Testing and Refinement**	**Production Ramp-up**
Automotive Company	No Inv.	Medium	Medium	High	High	Low
Electronics Company	No Inv.	Low	Medium	No Inv.	High	Low
Software Company	No Inv.	No Inv.	Medium	Low	Medium	Low
Heavy Equipment Company	No Inv.	No Inv.	Medium	Low	Medium	Low

Table 47: Summary of product support involvement across NPD stages

It seems that the Automotive Company is the company with the highest involvement of product support during the NPD process, followed by the Electronics Company (see Table 47). The Software and the Heavy Equipment companies, although they operate on different industries, show similar patterns in terms of product support involvement. Also the Testing and Refinement stage seems to be the stage with the highest involvement of product support in all companies. At this stage, product support offer their input with tools, reviews and tests on serviceability. It is also the stage where product support have more influence over the product, as, in all cases, they can "veto" the release of a product with the sign-off of the product design just before launch.

In the next chapter, a discussion of the overall findings will follow, in an effort to further explain the findings of this study.

CHAPTER 9. DISCUSSION OF RESULTS

9.1. Introduction

In the previous chapters, the main results of the research were presented. In this chapter, the findings will be discussed at a higher level, with the aim to give an overview of the approaches to product support taken by the different companies studied.

9.2. The Management Issue

9.2.1. The Problem

The issue investigated in this research could be described as follows. Customers are becoming more demanding in terms of more economical and efficient product support from the manufacturers (Loomba, 1996). Lele (1986) argues that a key factor influencing both the cost and the efficiency of product support is the product design. According to several researchers, the most important decisions are made at the design stage of the new product development process (Teresko, 1994; Gu and Sosale, 1999). Although support requirements should be among those decisions (Armistead and Clark, 1992; Teresko, 1994; Cespedes, 1995; Galloway, 1996; Goffin, 1998), Goffin (1998) found that product support is often ignored during the new product development process. In order to create easier to support products, product support should be taken into account in the NPD process. The study in question investigates the involvement of product support in the development processes in companies across different sectors.

9.2.2. Importance Of Including Product Support in NPD

From the literature, it has been recognized that product support:

- Is essential for achieving customer satisfaction and good long term relationships (Armistead and Clark, 1992; Athaide *et al*, 1996; Cespedes, 1995; Lele and Sheth, 1987; Teresko, 1994);
- Can provide a competitive advantage in markets where product differentiation becomes harder and companies are increasingly looking to service and support as a source of competitive advantage (Armistead and Clark, 1992; Goffin, 1998; Hull and Cox, 1994; Loomba, 1998);
- Plays a role in increasing the success rate of new products (Cooper and Kleinschmidt, 1993);
- Is a major source of revenue and profits for manufacturers (Hull and Cox, 1994);

It has been also recognised that product support needs to be fully evaluated during NPD, as good product design can make customer support more efficient and cost-effective (Armistead and Clark, 1992; Cespedes, 1995; Goffin, 1998).

Research in this area suggests that a study covering cases from a range of industries, as this would provide a better understanding of the role of support in NPD across the industries (Goffin, 1998). One of the propositions in Goffin and New's research (Goffin and New, 2001) was whether the products developed after a comprehensive evaluation of product support requirements has been made would be easier and cheaper to support than comparable products where this is not the case. Based on the above findings from

the literature research, this study aims to investigate the new product development processes in companies across different sectors and to examine in detail how product support interacts with the development teams and gets involved in the decisions regarding the product designs and the targets on the various elements of product support. In the following section, the findings of this thesis will be synoptically presented.

9.3. The Key Findings

The data for this study originated from four companies: an Automotive Company, which was the sponsoring company, and three other companies from three different industrial sectors: the electronics sector (Electronics Company), the heavy equipment manufacturing sector (Heavy Equipment Company) and the software sector (Software Company).

In order to compare easy to support with difficult to support products, two similar B2B products per case were selected based on three methods: a) opinion(s) of the service manager(s), b) product reviews and c) performance data of each of the candidate products on product support elements. Having made the selection of the two products, the development process of each one was studied and data were collected from two main sources in each company: a) semi-structured interviews with the managers that were involved in the development of each product and b) documentation regarding the development process employed and the product support.

The analysis of the data collected from each company gave some insight into the involvement of product support in the development processes in companies in different sectors. The findings of this thesis will be presented into two parts: a) the company by company findings and b) the cross-case analysis findings.

9.3.1. Company By Company Findings

The Automotive Company conducts a detailed analysis of the way every new product will be serviced. The product design goals which are set include the cost-of-ownership, the serviceability and the maintenance. In addition, a check is made of whether new cars solve prior model concerns and address damageability issues adequately. The latter is an assessment of how the cost of repairing the inevitable damage that will occur in common accidents can be minimised. The results of the analysis are summarised in the *Serviceability and Damageability Tool* document, which assesses the five issues mentioned, for each and every major component of a car.

In the case of the Electronics Company, product support, based partly on data from the field service engineers, provides an input into developing the requirements. However their role is not to set the targets, but to offer advice as to what these requirements should be. Although support are not a key decision maker in regard to the product requirement, the *Market Requirements Specification* document does contain references to the opinion that a product should be easy to use and have high levels of reliability. The document also contains specific service targets for the new product (for example, service intervals). Although these targets are agreed and set at the design stage they are seldom translated into design goals. Also, no model of total lifetime service cost was used at the Electronics Company. The point at which product support do have an input is during the testing stage. At this stage, prototypes undergo laboratory and field trials

in order to assess the functionality of the final product. During this stage, product support test the products and obtain feedback from customers who have been given prototypes to trial. At the end of the testing stage, product support have to sign off the final design of the product. Without their final approval the product cannot enter the next and final stage of the development process. However, once the product moves into the final stage the involvement of support is scaled back.

The Software Company are trying to improve the reliability and performance of their products from the system-level design stage. However, no actual product requirements are set towards these targets, leaving the relevant decisions to the discretion of the programmers. Product support may not be key decision makers in the development team but are there to provide all information that the team may need regarding the support of the product. As the product moves to the testing stage, product support increase their input, examining thoroughly the final products before getting them to the market. All product support targets (for example, errors per thousand lines of code) are dealing with the testing of the product, the stage where customers and technicians install prototypes of the software in laboratories or trial machines and give their feedback to the company. The results of the analyses are summarised in a document called the *Product Determination Scorecard*, which assesses mainly the serviceability of the product. Product support have to sign off the final design of the product, as without their final approval the product cannot enter the next and final stage of the development process.

Product support in Heavy Equipment Company participate actively in the development team. They focus on the elements of reliability, serviceability, diagnostics, upgradeability and cost of ownership at the system-level design stage, where the specifications for new products are set. However, the only direct product design goal set is the maintenance. In addition, a check is made of whether the new product solves prior model concerns and addresses serviceability issues adequately. The results of the analyses are summarised in a document called the *Customer Support Information Tool*, which assesses the six issues mentioned.

9.3.2. Cross-Case Findings

The first finding of the cross-case analysis indicates a greater involvement of product support across all companies in the easy to support products than in the difficult to support products. This involvement is in the form of providing input to the product development teams, setting targets as the product specifications and testing the product prototypes regarding service issues.

The second finding reveals that all companies, which are leaders in their areas, do consider support during the new product development process. The cross-case analysis shows that:

a) product support in the Automotive and the Electronics Companies have an input very early in the development process already from the concept development stage,
b) in all companies, product support give input in the system-level design stage, and
c) the testing & refinement is the stage where product support give the most input in the process in all companies

Another important finding is that only the Software and the Heavy Equipment Companies involve future customers in their tests. Customers use trial versions of the products and give their recommendations for any changes that could make the products more reliable and easier to use.

Product support is found to be significantly important to the customers of all four companies. In the Automotive Company, the brand manager quoted: "*The after-sales experience, what you can offer, will become much more of the differentiation between different manufacturers... the weight of the customer service and what happens in the process of getting the vehicle or actually owning the vehicle becomes more and more important*" ($I_{auto1MarketingMA}$). In the Electronics Company, the technical support manager noted: "*I think they are very important in as much as if it* [product support] *is wrong in the first place it impacts on them*" (I_{el1CSM}). In the Software Company, the Product A manager quoted: "*because we deal very much in the large end, you know, the enterprise end of the business, we are dealing with big companies that need that assurance of the large investments they are going to make, are going to be protected and they are not going to have to re-invest in a year's time or 18-month's time, they can service that investment over an extended period*" ($I_{sof1MarketingMA}$). Last but not least, the Product Manager UK of Heavy Equipment Company said: "[product support issues] *are probably the main differentiator between companies today is the support you provide after sales...There is probably less differentiation between products today than it was a few years ago. So then you look at what is the difference then. The difference is the overall service that the dealer provides to the customer. That would make the big difference*" ($I_{heav1MarketingUKM}$).

Regarding the new product development process, all companies employ a model that has stages and gates. However, the numbers of the stages varies from case to case. In Automotive Company, the number of stages is 9, in Electronics Company it is 6, and in the Software Company and in Heavy Equipment cases it is 5.

Another finding of this study refers to the indication of an increase of the level of product support involvement in the NPD process of the four companies through time. Apart from the Software Company case, where the two products were launched in the same year, in the other three cases there was a difference of at least two years in the launch dates of the two products. The involvement of product support is found to be greater in the product developed in the recent years than in the past.

In the next section, a discussion on the findings of the cross-case analysis will be presented, with reference to the literature.

9.4. Discussion

The cross-case analysis showed that product support was more involved in the easy to support products than in the difficult to support products. With the finding being verified in all four companies, it would be fair to argue that an increase of the involvement of product support in the product development process would lead to easier to support products. This argument supports the view of several researchers who contend that the design of new products could be improved from the feedback provided by the product support function (Lele, 1986; Mathe, 1986; Athaide, Meyers and Wilemon, 1996; Davenport and Klahr, 1998). Lele (1986) found that the product itself influences the amount of needed support after-sales. For example, he argued that the

product reliability and the maintenance and repair required are mainly dependent on the product design decisions. The findings of this study confirm that argument, as the reliability of the easy to support products was significantly higher than the reliability of the products that were difficult to support.

Goffin (1998) found that product support is often ignored during the new product development process or that many companies consider product support requirements late in the NPD process (Goffin, 2000). This study confirms the finding of Hull and Cox (1994) that leading companies consider support during the new product development process. The cross-case analysis shows that product support in two companies (Software and Heavy Equipment) started giving their input at the system-level design stage and in two companies (Automotive and Electronics) at the concept development stage, which is very early in the development process. No input of product support is found to exist during the planning stage. The bulk of the literature for the planning stage of product development support that this area is mostly devoted to marketing and strategy decisions about product portfolio selection (Cooper, Edgett and Kleinschmidt, 1997a), timing decisions (Krishnan and Ulrich, 1998), allocation of the development resources (Nobeoka, 1995; Nobeoka and Cusumano, 1997; Robertson and Ulrich, 1998) and the technologies to be incorporated in future products (Iansiti 1995b). No literature reference was found to suggest involvement of product support at the planning stage.

In this study, two of the case companies (the Software and the Heavy Equipment) involve customers during the testing stage of their product development processes. This type of customer involvement in the product development process was found in Boeing in the study of Knezevic (1999) as well. In this study, Knezevic noted that the development teams involved more than one customer airlines in the process and they were present all the way through the development process. This customer-focused new product development practice was identified in another study as a system of factors underlying the superior performance of firms in New Zealand (Souder, Buisson and Garrett, 1997). A third study in the North American telecommunication industry also found effective practices of new product development including customer feedback during the process of developing products (Mullins and Sutherland, 1998).

Another significant finding of the cross-case analysis points to the importance of product support to the customers and to the companies that create products based on it. Most of the managers' quotes referred to some of the advantages product support gives to the companies that employ it successfully. The first advantage is that it can give manufacturers a competitive advantage in a range of industries, including heavy equipment, computers, telecommunications hardware, and industrial machinery (Lele, 1986; Hull and Cox, 1994). For example, the Brand Manager in Europe of the Automotive Company emphasised: "*The after-sales experience, what you can offer, will become much more of the differentiation between different manufacturers*" ($I_{auto1MarketingMA}$). The second is that product support allows customers to gain maximum value from their purchases (Athaide, Meyers and Wilemon, 1996; Goffin and New, 2001). For the Manager of Current Products in the Heavy Equipment Company, providing quality product support to the customers is "*vitally important. Because the product the customer buys from us is a tool for him. He buys that, or he rents it or he leases it, whatever, but mostly buys this product to do a job. So it is not a status symbol or anything like that, it's a tool that he wants to do his job with, he needs it to be productive*" ($I_{heav1NPDM}$). The value of the product derives from the use of the product at

its best performance for a longer period of time throughout its life cycle or from the lower cost of ownership that occurs to the users of the product. Davidow (1986) noted that sophisticated customers tended to evaluate both the price of the product and the savings due to good service before buying high-tech equipment. The Manager of Customer Support UK in the Heavy Equipment Company noted: "[Product support] *is very strongly influencing the buying behaviour, because serviceability tends to go to some degree with reliability and durability, and the three together is what drives the second-hand value of the product. And the second-hand value is what drives the new equipment sales, if it is worth good money in three years time then it is economic good sense to buy a new one*" ($I_{heav1CSUKM}$). The partner relationship, developed between the dealer or the company and the customer, might lead to customer loyalty with direct benefits for the manufacturers both before and after the actual product sale (Teresko, 1994; Cespedes, 1995; Athaide, Meyers and Wilemon, 1996) due to repeated and increased business (Lewis, 1995; Aschner, 1999).

As far as the process of developing the new products is concerned, it was found that all companies employed a similar process to the Stage-Gate approach (see Figure 2) suggested by Cooper (1993). Although several models exist in the literature (see chapter 2), the Stage-Gate approach is the kind of model all companies seem to still employ for the development of their products. Their models, as the Stage-Gate approach, include several review points during the product development process, in which the new product creation could have been continued or aborted.

The data analysis shows that the involvement of product support is greater in the product developed in recent years than in the past. There might be several reasons for this. Customers are becoming more demanding in terms of more economical cost of ownership from the manufacturers (Loomba, 1996). In many industries the "down-time costs run typically at anywhere from 100 to 10,000 times the prices of spare parts or service" (Knecht, Leszinski and Weber, 1993), showing the need for fast and efficient repair. There are many ways to reduce the down-time costs. The first way is to produce equipment that is very reliable (or never fails) (Davidow, 1986). Another way, proposed by Lele and Karmarkar (1983), is the rapid response to expedite repairs, through the use of diagnostics (Hegde and Kubat, 1989) and the fast expedition of spare parts (Hull and Cox, 1994). As the design of the product has an immediate effect on the product's reliability and, consequently, on the frequency of its maintenance and repair (Lele, 1986), one can argue that both ways described previously require a well organised product support department and its extensive involvement in the product design decisions.

9.5. Summary

The analysis of the data collected shows that product support is really important to the customers of the case companies, although different elements apply to different industrial sectors. It also shows a link between the involvement of product support in the development process and the serviceability of the final product. Product support is found to be more involved in the easy to support products than in the difficult to support products. In the next chapter, an initial overview of the findings will lead to the proposition of several solutions for the improvement of the efficiency of this involvement. In addition, a number of recommendations will be presented for future work, hoping that it will excite researchers to further examine this interesting issue.

CHAPTER 10. CONCLUSION

10.1. Introduction

In the previous chapter an overview of the main issues dealt with in this research was presented, with reference to the relevant literature. In this concluding chapter, the findings of the study are synoptically quoted. Along with these results, a number of recommendations are proposed concerning the involvement of product support in the new product development process. Aware of its limitations, this study will finish with propositions for future research in the field of product support.

10.2. Key Findings

To allow the reader to review the main areas of concern of this study the following table is presented (Table 48).

Research Questions
1) How product support requirements are incorporated in the new product development processes in different companies in several industrial sectors 2) At what stage of the NPD process is product support providing their input?
Companies
1. Automotive company (pilot study)
2. Electronics company
3. Software company
4. Heavy Equipment company
Sources used to collect data
1. Semi-structured interviews with managers
2. Semi-structured interviews with customers (were possible)
3. Documents regarding the NPD process and other related issues
4. Product review interview with a manager from the product support department
5. Performance data collected from Post-launch Documents
Findings
1. Product support was more involved in the easy to support products than in the difficult to support products
2. All companies had product support participating in their development processes
3. Product support in Automotive and Electronics company started their input in the concept development stage
4. In all companies product support gave input in the system-level design stage
5. The testing & refinement was the stage where in all companies gave the most input
6. Only Software company and Heavy Equipment company involved customers in their tests
7. Product support was found important to the customers of all four companies
8. All companies employed a stage-gate model of product development
9. Increase of the level of product support involvement in the NPD processes through time

Table 48: Synopsis of the study

Based on the argument that product support should be taken into account when developing new products in order to create easier to support products, the study in question investigated the involvement of product support in the development processes in companies across different sectors. The analysis of the information gathered from each company gave some insight into the involvement of product support in the development processes in companies in different sectors. The companies that participated were leaders in their sectors and they all had product support departments that were involved in their new product development processes. The processes employed for the development of new products were all based on the stage-gate model, with the Automotive Company having the most stages (i.e. 9) and the Software and the Heavy Equipment Companies the least (i.e. 5). Decision checkpoints (gates) were set at the end of each stage in all companies in order for the new product to proceed in the development process and product support had to sign-off at least at the last gate before the production of the product and its launch in the marketplace.

It was found that in all companies, product support was more involved in the easy to support products than in the difficult to support products. There was no input of product support at the planning stage at any company. Only in Automotive and Electronics Companies product support had involvement in concept development, the second stage of the product development process. The research reveals that in all companies product support gave input in the system-level design stage. Furthermore, the testing & refinement was the stage where in all companies gave the most input in the process. This input had the form of providing information to the product development teams, setting support targets as product specifications and testing of the product prototypes with regards to service. It would therefore be fair to argue that an increase of the involvement of product support in the product development process would lead to easier to support products.

From the interviews with the managers and some customers it was revealed that product support was an important factor to the customers of all four companies when making purchasing decisions on industrial equipment or infrastructure systems software products. Nevertheless, only the Software and Heavy Equipment companies involved future customers in their tests in an effort to assess the ease of use and any defects of their products. The information collected was then fed back to the development process and, depending on the nature and the importance of the required changes, it lead to product changes or put into consideration for the next version of the products.

The study investigates the product support input in the development process of two products per company. In the three cases (apart from the software company where both products were launched in the same year), the products were launched in the markets with a difference of at least two years. From the cross-case analysis, an increase of the level of product support involvement in the NPD processes of those companies through time was observed, leading to the indication that the involvement of product support was greater in the products developed in recent years than in the past.

10.3. Contribution To Knowledge And Research

The overall purpose of this research work was to reach a better understanding of product support involvement in the NPD process. So far little is known about the product support and the new product development process. Most of the research projects conducted focused on investigating individual and isolated cases. The objective

of this research project is to investigate the product support involvement in NPD across a number of different companies. The literature review identified a knowledge and research gap, a need for a better understanding of how product support requirements are evaluated at the design stage of new products. This research project focused on how the evaluation of product support requirements is made and at what stage of the NPD process these product support requirements are taken into account.

In order to view inside the NPD process in different companies the case study research approach was applied. By adopting this approach the researcher aimed to investigate the product support organisations inside the companies, the actions taken during the NPD process and the targets that were set as specifications for the new product designs. Two products of the same nature but different in terms of the performance on the product support elements were selected in each company, in an effort to identify differences between the easy to support and the difficult to support products in terms of product support involvement during the NPD process.

This detailed investigation of product support provides a comprehensive and grounded view on the product support involvement during the NPD process. The final research outcome of this research work derived inductively, grounded on a series of different case studies empirically conducted.

Hence, the research findings are not based on one individual case in a distinct environment. The research findings are based on a number of cross-case analysis across four different companies in a variety of different environmental settings. This multi-case study approach increases the generalisability of the final research product.

Many research works and research publications often just state what the product support managers offer to the development of new products. On the contrary, this research project takes a step deeper inside the NPD teams and investigates the involvement of product support, the actions and targets set and the influence of product support. Active members of the NPD teams, which were managers from different disciplines that participated in these teams, were asked to comment on the input of product support and the impact of this input to the final product design. This broad cross-disciplinary approach gave the opportunity to seek for negative evidence, thus increasing the internal validity of this research work.

Furthermore, in contrast to other research work, this research project views the development of new products from the initial idea to design, testing and production of new products from a product support perspective. Together with the direct comparison of two products within each case, this work points out the differences of the practices employed between similar products with different product support performances and between companies operating in different industries. Companies from some of these industries have been investigated in previous research projects. However, this study included an infrastructure systems software company, an unexplored area by previous researchers in the area of product support.

Besides an academic contribution, this research work has practical implications and applications. The practical implications are, for example, to provide additional knowledge to existing product support organisations in respect to their present organisational set-up and their day-to-day input in the development of new products. They could, for example, benchmark their present input in the NPD process against the

cases presented here in order to identify weaknesses and missing opportunities, or just to get a new or additional ideas on how to improve their current practices. Another practical application could be to guide companies in sectors other than the ones investigated in this research project as to what is considered as leading practice in other industries and how this practice has been applied through the product support actions and targets during the NPD process.

The results enable a number of practical recommendations to be made for product support managers involved in the NPD process:

- Monitor the effectiveness of product support strategies for the current line of products
- When designing new products, consider the importance, from the customer perspective, of both product attributes and support services
- Measure real customers' perceptions of not only competitive products but also competitive support services
- Set quantitative design goals for all elements of product support and check that these are implemented during product development
- Promote the right mix of product and support services to gain a competitive advantage

10.4. Limitations Of This Research

Limitations of this research concern both the scope of the issues studied and the methodology used.

One of the key methodological limitations of case study research is external validity. The use of a small sample challenges the generalisability of the findings. In this research, the four cases presented are leading companies in terms of product support in their industrial sectors. The findings of the thesis consist a detailed guide for the necessity of introducing product support in the NPD process. However, they would certainly have limitations when employed to other companies operating in the respecting sectors. For example, small organisations may not necessarily need to implement a formal planning process for product support. To address this limitation, a wide survey of companies' practices could help generalise the findings from the cases.

Another methodological limitation concerns internal validity. Triangulation was employed during the data collection. Documents related to the NPD process and the product support were collected, performance data and product reviews with the support managers were used for the product selection, in addition to the numerous interviews with the managers of each case company. However, much of the data collected was "manager reported". Some of the findings are based entirely on the managers' quotes, as it proved impossible to locate or have access to a document that contained support for the claims they made. Longitudinal studies in which researchers are present at key design meetings and actually observe the process of evaluation and implementation of product support requirements could effectively address this issue.

An additional limitation is due to the fact that all variables influencing the performance of a product on the product support elements could not be investigated in this case study research. For example, informants perceived advantages in designing products for easy and efficient support but these advantages were not quantified in any way. Informants presumed that designing products with serviceability in mind would make

new products easier to support and consequently reduce cost-of-ownership and in several cases had anecdotal evidence. However, further research is needed in order to address this point.

10.5. Further Research

This study was a detailed investigation of the involvement of product support in the new product development processes of eight products in total. The four companies that participated provided the researcher with detailed information, both in terms of documents and interviews, and revealed most of the relevant data regarding their products. However, the practices employed by these companies are not exactly representatives of the approach on product support by the whole industrial sector they belong, as all companies selected are leaders in their sector in terms of support. A wide survey of companies' practices, ideally covering several industrial sectors, especially the ones investigated here, is imperative in order to generalise the findings from the cases on the involvement of product support in the development process.

Research in product support and NPD is at the level of exploration. Many issues are still available for research in this area. For example, there is no indication of a proportional percentage of companies in different industrial settings that use product support as a competitive advantage, taking into account metrics of overall business performance (return on investment, market share, sales growth) or product success. Another important issue that has emerged is the decision-making process regarding the product development process. As many decisions are made when developing new products, it would be extremely interesting to see what priority is given to product support elements comparing to marketing or manufacturing priorities. In particular, it could be useful (a) to identify preference patterns of customer support and NPD managers towards product design parameters (e.g. will R&D managers more quickly trade-off performance against serviceability, when designing a new product, than the customer support managers?) and (b) to capture information on "ideal" product design as seen by the decision makers in the new product development teams. The conceptual framework of conjoint analysis could address the issue of designing a supply chain and of detecting patterns of preferences among respondents in a sample.

Another issue emerging in this research is the lack of an investigation of whether products designed for easier support actually achieve their targets (e.g. in reducing the cost-of-ownership or mean time between failures). When product support was more involved in the product development process, the products were improved in terms of product support elements. However it is difficult to directly link product design with the quality of product support provided. By consequence, the process and/or guidelines for introducing product support through 'Design for Supportability' in new products have not been identified. Descriptive goals/measures for introducing product support in new product development are required, together with a theoretical grounding of the findings.

The impact product support has during the development process of new products is mainly dependant on the information the company's product support organisation collects and on the knowledge of the after-sales requirement of their customers. Future research could look into how customers' support requirements are investigated and recorded by product support organisations across different industrial sectors. The

transfer of knowledge on product support from the product support function to the marketing and manufacturing functions is also a field that requires further investigation.

Finally it would be extremely interesting to investigate the area of customer satisfaction and the role product support has in it. An investigation of buyers' (clients) expectations/needs of product support regarding different types of products (or industries) could be helpful in order to better understand the support requirements from the customers' point of view in different industrial settings.

10.6. A Final Word...

This research hopes to have broadened the knowledge of product support, not only in theoretical but also in practical terms. A number of important recommendations, that could potentially increase the quality of product support and lead to increased customer satisfaction, have been addressed and could be found useful by product support managers who are involved in the development of new products.

Further researching on the perspectives of both the customers and the industrial sector on the relationship between 'Product design – product support – customer satisfaction' seems to be required. The present research could provide a detailed basis for future work in this under researched area.

Research in any field should not be considered an end in itself. It is hoped that the conclusions of this research will find practical applications and lead to improvements in the quality of product support.

CHAPTER 11. REFERENCES

A

Adler, P. S., Mandelbaum, A., Nguyen, V. and Schwerer, E. (1995), 'From Project to Process Management: An Empirically-based Framework for Analyzing Product Development Time'. *Management Science,* Vol. 41, No. 3, pp. 458-484.

AitSahlia, F., Johnson, E. and Will, P. (1995), 'Is Concurrent Engineering Always a Sensible Proposition?'. *IEEE Transactions on Engineering Management,* Vol. 42, No. 2, pp. 166-170.

Ali, A., Kalwani, M. U. and Kovenock, D. (1993), 'Selecting Product Development Projects: Pioneering versus Incremental Innovation Strategies'. *Management Science,* Vol. 39, No. 3, pp. 255-274.

Anagnostopoulos, Z., Goffin, K. and Szwejczewski, M. (2001), 'Design For Supportability: Leading edge practices'. *AFSM International - The Professional Journal,* Vol. 26, No. 3, pp.

Anthoney, M. T. and McKay, J. (1992), 'Balancing the product development process achieving product and cycle-time excellence in high-technology industries'. *Journal of Product Innovation Management,* Vol. 9, No. 2, pp. 140-147.

Armistead, C. G. and Clark, G. (1992), *Customer Service and Support.* London: Pitman.

Aschner, G. S. (1999), 'Meeting customers' requirements and what can be expected'. *The TQM Magazine,* Vol. 11, No. 6, pp. 450-455.

Athaide, G. A., Meyers, P. W. and Wilemon, D. L. (1996), 'Seller-Buyer Interactions During the Commercialization of Technological Process Innovations'. *Journal of Product Innovation Management,* Vol. 13, No. 5, pp. 406-421.

B

Bacon, G., Beckman, S., Mowery, D. and Wilson, E. (1994), 'Managing Product Definition in High Technology Industries: A Pilot Study'. *California Management Review,* Vol. 36, No. 3, pp. 32-56.

Baldwin, C. Y. and Clark, K. B. (1997), 'Managing in an age of modularity'. *Harvard Business Review,* Vol. 75, No. 5, pp. 84-93.

Bayus, B. L., Jain, S. and Rao, A. G. (1997), 'Too Little, Too Early: Introduction Timing and New Product Performance in the Personal Digital Assistant Industry'. *Journal of Marketing Research,* Vol. 34, No. 1, pp. 50-63.

Benedetto, A. C. D. (1999), 'Identifying the Key Success Factors in New Product Launch'. *Journal of Product Innovation Management,* Vol. 16, No. 6, pp. 530-544.

Bhattacharya, S., Krishnan, V. and Mahajan, V. (1998), 'Managing New Product Definition in Highly Dynamic Environments'. *Management Science,* Vol. 44, No. 11, Part 2 of 2, pp. 550-564.

Blanchard, B. S. (1991), 'The impact of Integrated Logistics Support on total cost-effectiveness of a system'. *International Journal of Physical Distribution and Logistics Management,* Vol. 21, No. 5, pp. 23-26.

Bliss, J., Ogborn, J. and Grize, F. (1979), 'The Analysis of Qualitative Data'. *European Journal of Science Education,* Vol. 1, No. 4, pp. 427-440.

Boothroyd, G., Dewhurst, P., Knight, W. A. and Dekker, M. (1994), *Product Design for Manufacturing*. New York: M. Dekker.

Bouckaert, K., Deneffe, D. and Vantrappen, H. (1997), 'How Product Companies Are Competing Through Services'. *Prism,* Vol., No. Fourth Quarter 1997, pp. 29-41.

Bowen, D. E., Siehl, C. and Schneider, B. (1989), 'A framework for analysing customer service orientations in manufacturing'. *Academy of Management Review,* Vol. 14, No. 1, pp. 75-95.

Brown, A. and Dowling, P. (1998), *Doing Research Reading Research: A Mode of Interrogation for Education*. London: Falmer Press.

Burger, P. C. and Cann, C. W. (1995), 'Post-Purchase Strategy - A Key to Successful Industrial Marketing and Customer Satisfaction'. *Industrial Marketing Management,* Vol. 24, No. 2, pp. 91-98.

C

Cespedes, F. V. (1995), *Concurrent Marketing*. Boston: Harvard Business School Press.

Clark, K. B. (1989), 'Project scope and project performance: The effect of parts strategy and supplier involvement on product development'. *Management Science,* Vol. 35, No. 10, pp. 1247-1263.

Clark, K. B. and Fujimoto, T. (1991), *Product Development Performance*. Boston: Harvard Business School.

Cohen, M. A., Eliasberg, J. and Ho, T.-H. (1996), 'New Product Development: The Performance and Time-to-Market Tradeoff'. *Management Science,* Vol. 42, No. 2, pp. 173-186.

Cohen, M. A. and Whang, S. (1997), 'Competing in product and service: a product life-cycle model'. *Management Science,* Vol. 43, No. 4, pp. 535-545.

Connor, D. (1999), 'Dell adopts online support; Compaq soon to follow'. *Network World,* Vol. 16, August 1999, pp. 1,77.

Cooper, R. G. (1993), *Winning at New Products*. Reading, MA: Addison-Wesley Publishing Company.

Cooper, R. G. (1999), 'From Experience: The Invisible Success Factors in Product Innovation'. *Journal of Product Innovation Management,* Vol. 16, No. 2, pp. 115-133.

Cooper, R. G., Edgett, S. J. and Kleinschmidt, E. J. (1997a), 'Portfolio Management in New Product Development: Lessons from the Leaders-I'. *Research-Technology Management,* Vol. 40, No. 5, pp. 16-28.

Cooper, R. G., Edgett, S. J. and Kleinschmidt, E. J. (1997b), 'Portfolio Management in New Product Development: Lessons from the Leaders-II'. *Research-Technology Management,* Vol. 40, No. 6, pp. 43-52.

Cooper, R. G. and Kleinschmidt, E. J. (1993), 'Major New Products: What Distinguishes the Winners in the Chemical Industry'. *Journal of Product Innovation Management,* Vol. 10, No. 2, pp. 90-111.

D

Davenport, T. H. and Klahr, P. (1998), 'Managing Customer Support Knowledge'. *California Management Review,* Vol. 40, No. 3, pp. 195-208.

Davidow, W. H. (1986), *Marketing High Technology: An Insider's View*. New York: The Free Press.

DeGroote, X. (1994), 'Flexibility and marketing/manufacturing coordination'. *International Journal of Production Economics,* Vol. 36, No. 2, pp. 153-167.

de Vaus, D. A. (1996), *Surveys in Social Research.* (4th ed.). London: UCL Press.
Dowling, P. (2001), *Social Activity Theory* (Working Paper). London: Institute Of Education.

Dobson, G. and Kalish, S. (1993), 'Heuristics for Pricing and Positioning a Product-line Using Conjoint and Cost Data'. *Management Science,* Vol. 39, No. 2, pp. 160-175.

Donaldson, W. G. (1995), 'Manufacturers Need to Show Greater Commitment to Customer Service'. *Industrial Marketing Management,* Vol. 24, No. 5, pp. 421-430.

Dougherty, D. (1992), 'Interpretive barriers to successful product innovation in large firms'. *Organization Science,* Vol. 3, No. 2, pp. 179-202.

E

Ealey, L. A. and Troyano-Bermudez, L. (2000), 'The automotive industry: A 30,000-mile checkup'. *The McKinsey Quarterly,* Vol., No. 1, pp. 72-79.

El Sawy, O. A. and Bowles, G. (1997), 'Redesigning the customer support process for the electronic economy: insights from Storage Dimensions'. *MIS Quarterly,* Vol. 21, No. 4, pp. 457-483.

Emerson, C. J. and Grimm, C. M. (1996), 'Logistics and marketing of customer service: an empirical test of the Mentzer, Gomes and Krapfel model'. *International Journal of Physical Distribution and Logistics Management,* Vol. 26, No. 8, pp. 29-42.

Emerson, C. J. and Grimm, C. M. (1998), 'The relative importance of logistics and marketing customer service: a strategic perspective'. *Journal of Business Logistics,* Vol. 19, No. 1, pp. 17-32.

Emerson, C. J. and Grimm, C. M. (1999), 'Buyer-seller customer satisfaction: the influence of the environment and customer service'. *Journal of Business & Industrial Marketing,* Vol. 14, No. 5/6, pp. 403-415.

F

Fites, D. V. (1996), 'Make Your Dealers Your Partners'. *Harvard Business Review,* Vol. 74, No. 3, pp. 40-51.

Fortuin, L. and Martin, H. (1999), 'Control of service parts'. *International Journal of Operations & Production Management,* Vol. 19, No. 9, pp. 950-971.

Fowler Jr, F. J. (1984), *Survey Research Methods*. Beverly Hills, California: Sage Publications.

G

Galloway, I. (1996), 'Design for support and support the design: integrated logistics support - the business case'. *Logistics Information Management,* Vol. 9, No. 1, pp. 24-31.

Gilmour, P., Borg, G., Duffy, P. A., Johnston, N. D., Limbek, B. E. and Shaw, M. R. (1977), 'Customer Service: Differentiating by Market Segment'. *International Journal of Physical Distribution,* Vol. 7, No. 3, pp. 141-148.

Goffin, K. (1990), 'Design for support: results of a UK survey'. *AFSM International - The Professional Journal,* Vol. 14, No. 2, pp. 14-15.

Goffin, K. (1994), 'Gaining a Competitive Advantage from Support: Five Case Studies'. *European Services Industry,* Vol. 1, No. 4, pp. 1, 5-7.

Goffin, K. (1998), 'Customer Support and New Product Development - An Exploratory Study'. *Journal of Product Innovation Management,* Vol. 15, No. 1, pp. 42-56.

Goffin, K. (1999), 'Customer support: A cross-industry study of distribution channels and strategies'. *International Journal of Physical Distribution and Logistics Management,* Vol. 29, No. 6, pp. 374-397.

Goffin, K. (2000), 'Design for Supportability: An Essential Component of New Product Development'. *Research-Technology Management,* Vol. 43, No. 2, pp. 40-47.

Goffin, K. and New, C. (2001), 'Customer Support and New Product Development - An exploratory study'. *International Journal of Operations & Production Management,* Vol. 21, No. 3, pp. 275-301.

Goffin, K., Szwejczewski, M. and New, C. (1997), 'Managing Suppliers: When Fewer Can Mean More'. *International Journal of Physical Distribution and Logistics Management,* Vol. 27, No. 7, pp. 422-436.

Green, P. E. and Srinivasan, V. (1990), 'Conjoint Analysis in Marketing: New Developments With Implications for Research and Practice'. *Journal of Marketing,* Vol. 54, No. 4, pp. 3-19.

Griffin, A. (1993), 'Metrics for Measuring Product Development Cycle Time'. *Journal of Product Innovation Management,* Vol. 10, No. 2, pp. 112-125.

Griffin, A. (1997), 'The Effect of Project and Process Characteristics on Product Development Cycle Time'. *Journal of Marketing Research,* Vol. 34, No. 1, pp. 24-35.

Griffin, A. and Hauser, J. R. (1996), 'Integrating R&D and Marketing: A Review and Analysis of the Literature'. *Journal of Product Innovation Management,* Vol. 13, No. 3, pp. 191-215.

Gu, P. and Sosale, S. (1999), 'Product modularization for life cycle engineering'. *Robotics and Computer Integrated Manufacturing,* Vol. 15, No. 5, pp. 387-401.

H

Ha, A. Y. and Porteus, E. L. (1995), 'Optinal Timing of Reviews in Concurrent Design for Manufacturability'. *Management Science,* Vol. 41, No. 9, pp. 1431-1447.

Haggblom, T., Calantone, R. J. and Benedetto, A. C. D. (1995), 'Do New Product Development Managers in Large or High-Market-Share Firms Perceive Marketing-R&D Interface Principles Differently?'. *Journal of Product Innovation Management,* Vol. 12, No. 4, pp. 323-333.

Hauser, J. R. and Clausing, D. (1988), 'The House of Quality'. *Harvard Business Review,* Vol. 66, No. May-June 1988, pp. 63-73.

Hegde, G. G. and Kubat, P. (1989), 'Diagnostics design: A product support strategy'. *European Journal of Operational Research,* Vol. 38, No. 1, pp. 35-43.

Hendricks, K. B. and Singhal, V. R. (1997), 'Delays in New Product Introductions and the Market Value of the Firm: The Consequences of Being Late to the Market'. *Management Science,* Vol. 43, No. 4, pp. 422-436.

Hise, R. T., O'Neal, L., Parasuraman, A. and McNeal, J. U. (1990), 'Marketing/R&D Interaction in New Product Development: Implications for New Product Success Rates'. *Journal of Product Innovation Management,* Vol. 7, No. 2, pp. 142-155.

Hull, D. L. and Cox, J. F. (1994), 'The field service function in the electronics industry: Providing a link between customers and production/marketing'. *International Journal of Production Economics,* Vol. 37, No. 1, pp. 115-126.

H

Iansiti, M. (1995a), 'Shooting the Rapids: Managing Product Development in Turbulent Environments'. *California Management Review,* Vol. 38, No. 1, pp. 37-58.

Iansiti, M. (1995b), 'Technology Development and Integration: An Empirical Study of the Interaction Between Applied Science and Product Development'. *IEEE Transactions on Engineering Management,* Vol. 42, No. 3, pp. 259-269.

Iansiti, M. and Clark, K. B. (1994), 'Integration and Dynamic Capability: Evidence from Product Development in Automobiles and Mainframe Computers'. *Industrial and Corporate Change,* Vol. 3, No. 3, pp. 557-605.

Ionzon, K. and Holmqvist, T. (2005), 'Integrating service aspects in new product development'. *12th International Product Development Management Conference,* Copenhagen, Denmark, June 13-14, pp. 637-650.

Ivory, C.J., Thwaites, A.T. and Vaughan, R. (2003), 'Shifting the Goal Posts for Design Management in Capital Goods Projects: "Design for Maintainability"'. *R&D Management,* Vol. 33, No. 5, pp. 527-538.

K

Kalish, S. and Lilien, G. L. (1986), 'A market entry timing model for new technologies'. *Management Science,* Vol. 32, No. 2, pp. 194-205.

Kalyanaram, G. and Krishnan, V. (1997), 'Deliberate Product Definition: Customizing the Product Definition Process'. *Journal of Marketing Research,* Vol. 34, No. 2, pp. 276-285.

Karmarkar, U. S. and Kubat, P. (1987), 'Modular product design and product support'. *European Journal of Operational Research,* Vol. 29, No. 1, pp. 74-82.

Kekre, S., Krishnan, M. S. and Srinivasan, K. (1995), 'Drivers of Customer Satisfaction for Software Products: Implications for Design and Service Support'. *Management Science,* Vol. 41, No. 9, pp. 1456-1470.

Kekre, S. and Srinivasan, K. (1990), 'Broader product line: A necessity to achieve success?'. *Management Science,* Vol. 36, No. 10, pp. 1216-1230.

Knecht, T., Leszinski, R. and Weber, F. A. (1993), 'Memo to a CEO: Making profits after the sale'. *The McKinsey Quarterly,* Vol., No. 4, pp. 79-86.

Knezevic, J. (1999), 'Chief mechanic: the new approach to aircraft maintenance by Boeing'. *Journal of Quality in Maintenance Engineering,* Vol. 5, No. 4, pp. 314-324.

Kohli, R. and Sukumar, R. (1990), 'Heuristics for product-line design using conjoint analysis'. *Management Science,* Vol. 36, No. 12, pp. 1464-1478.

Krishnan, V., Eppinger, S. D. and Whitney, D. E. (1997), 'A Model-Based Framework to Overlap Product Development Activities'. *Management Science,* Vol. 43, No. 4, pp. 437-451.

Krishnan, V. and Ulrich, K. T. (1998), *Product Development Decisions: A Review of the Literature* (Working Paper). Philadelphia: Department of Operations and Information Management, The Wharton School.

Kyj, L. S. and Kyj, M. J. (1989), 'Customer Service: Product Differentiation in International Markets'. *International Journal of Physical Distribution & Materials Management,* Vol. 19, No. 1, pp. 30-38.

L

Lee, H. L. (1996), 'Effective inventory and service management through product and process redesign'. *Operations Research,* Vol. 44, No. 1, pp. 151-159.

Lele, M. M. (1986), 'How Service Needs Influence Product Strategy'. *Sloan Management Review,* Vol. 28, No. 1, pp. 63-70.

Lele, M. M. (1997), 'After-sales service - necessary evil or strategic opportunity?'. *Managing Service Quality,* Vol. 7, No. 3, pp. 141-145.

Lele, M. M. and Karmarkar, U. S. (1983), 'Good Product Support is Smart Marketing'. *Harvard Business Review,* Vol. 61, No. 6, pp. 124-132.

Lewis, B. R. (1995), 'Customer Care in Services'. In W. J. Glynn and J. g. Barnes (eds), *Understanding Services Management* (1st ed., pp. 57-88). Chichester: Wiley.

Little, D., Mosquera, J. and Wild, A. M. A. (1988), 'Logistics for Service Support in the Computer Industry'. *Focus on Physical Distribution & Logistics Management,* Vol. 7, No. 2, pp. 30-35.

Livingston, I. (1988, 29-30 November), *Design for service.* Paper presented at the First International Conference on After-sales Success, London.

Loomba, A. P. S. (1996), 'Linkages between product distribution and service support functions'. *International Journal of Physical Distribution and Logistics Management,* Vol. 26, No. 4, pp. 4-22.

Loomba, A. P. S. (1998), 'Product Distribution and Service Support Strategy Linkages: An Empirical Investigation'. *International Journal of Physical Distribution and Logistics Management,* Vol. 28, No. 2, pp. 143-161.

M

MacCormack, A. (2001), 'Product-Development Practices That Work: How Internet Companies Built Software'. *Sloan Management Review,* Vol. 42, No. 2, pp. 75-85.

Maffin, D. and Braiden, P. (2001), 'Manufacturing and supplier roles in product development'. *International Journal of Production Economics,* Vol. 69, No. 2, pp. 205-213.

Mahajan, V. and Wind, J. (1992), 'New Product Models: Practice, Shortcomings and Desired Improvements'. *Journal of Product Innovation Management,* Vol. 9, No. 2, pp. 128-139.

Mahoney, J. T. (1992), 'The choice of organizational form: Vertical financial ownership versus other methods of vertical integration'. *Strategic Management Journal,* Vol. 13, No. 8, pp. 559-584.

Markeset, T. and Kumar, U. (2003), 'Integration of RAMS and Risk Analysis in Product Design and Development Work Processes: A Case Study'. *Journal of Quality in Maintenance Engineering,* Vol. 9, No. 4, pp. 393-410.

Marsan, C. D. (2000), 'Help yourself to e-support'. *Network World,* Vol. 17, August 28, pp. 1,80.

Mathe, H. (1986), 'Field Service Management: A means to competitive advantage'. *International Journal of Physical Distribution and Materials Management,* Vol. 16, No. 7, pp. 13-21.

Mercer, M. (1999), 'Cat launches skid-steers: let the games begin! Caterpillar introduces 1350 and 1500 lb skid steer loaders.'. *Diesel Progress North American Edition,* Vol. 65, March 1999, pp. 22.

Miles, M. B. and Huberman, M. A. (1994), *Qualitative Data Analysis: An Expanded Sourcebook.* (2nd ed.). Thousand Oaks: Sage Publications.

Millson, M. R., Raj, S. P. and Wilemon, D. L. (1992), 'A Survey of Major Approaches for Accelerating New Product Development'. *Journal of Product Innovation Management,* Vol. 9, No. 1, pp. 53-69.

Miskie, R. (1989), 'Documentation: Not a "Necessary Evil" but a Valuable Resource'. *Network World,* Vol. 6, No. 8, pp. 35.

Moenaert, R. K., Souder, W. E., De Meyer, A. and Deschoolmeester, D. (1994), 'R&D-Marketing Integration Mechanisms, Communication Flows, and Innovation Success'. *Journal of Product Innovation Management,* Vol. 11, No. 1, pp. 31-45.

Morelli, M. D., Eppinger, S. D. and Gulati, R. K. (1995), 'Predicting Technical Communication in Product Development Organizations'. *IEEE Transactions on Engineering Management,* Vol. 42, No. 3, pp. 215-222.

N

Nobelius, D. and Sundgren, N. (1998), *Exploring parts sharing in manufacturing firms - Highlighting managerial difficulties in product development.* Paper presented at the IEEE IEMC '98.

Nobeoka, K. (1995), 'Inter-project learning in new product development'. *Academy of Management Journal,* Vol., No., pp. 432-436.

Nobeoka, K. and Cusumano, M. A. (1997), 'Multiproject strategy and sales growth: The benefits of rapid design transfer in new product development'. *Strategic Management Journal,* Vol. 18, No. 3, pp. 169-186.

O

Oppenheim, A. N. (1992), *Questionnaire Design, Interviewing and Attitude Measurement.* London: Cassell.

P

Papalambros, P. Y. (1995), 'Optimal Design of Mechanical Engineering Systems'. *Journal of Mechanical Design,* Vol. 117, No. Special Issue, pp. 55-62.

Parasuraman, A. (1998), 'Customer service in business-to-business markets: an agenda for research'. *Journal of Business & Industrial Marketing,* Vol. 13, No. 4/5, pp. 309-321.

Parker, K. (1993), 'Being Green Doesn't Hurt'. *Manufacturing Systems,* Vol. 11, No. 10, pp. 31-36.

Perreault, W. D. J. and Russ, F. A. (1974), 'Physical Distribution Service: A Neglected Aspect of Marketing Management'. *MSU Business Topics,* Vol. 22, No. 3, pp. 37-45.

Phelan, A., Griffiths, J. and Fisher, S. (2000), 'Pushing worldwide aftermarket support of manufactured goods'. *Managing Service Quality,* Vol. 10, No. 3, pp. 170-177.

Poolton, J. and Barclay, I. (1998), 'New Product Development From Past Research to Future Applications'. *Industrial Marketing Management,* Vol. 27, No. 3, pp. 197-212.

R

Rackham, N. (1998), 'From Experience: Why Bad Things Happen to Good New Products'. *Journal of Product Innovation Management,* Vol. 15, No. 3, pp. 201-207.

Ramaswamy, R. and Ulrich, K. (1993), 'Augmenting the House of Quality with Engineering Models'. *Research in Engineering Design,* Vol. 5, No. 2, pp. 70-79.

Reason, P. and Bradbury, H. (eds) (2001), *Handbook of Action Research: Participative Inquiry and Practice.* London: Sage Publications.

Robertson, D. and Ulrich, K. (1998), 'Planning for Product Platforms'. *Sloan Management Review,* Vol. 39, No. 4, pp. 19-31.

S

Sanchez, R. and Mahoney, J. T. (1996), 'Modularity, flexibility, and knowledge management in product and organization design'. *Strategic Management Journal,* Vol. 17, No. Special Issue Winter, pp. 63-76.

Sapsford, R. (1999), *Survey Research.* London: Sage Publications.

Sleeter, M. (1991), 'How product usability impacts the service organization'. *AFSM International - The Professional Journal,* Vol. 16, No. 2, pp. 59-61.

Smith, R. P. and Eppinger, S. D. (1997a), 'Identifying Controlling Features of Engineering Design Decision'. *Management Science,* Vol. 43, No. 3, pp. 276-293.

Smith, R. P. and Eppinger, S. D. (1997b), 'A Predictive Model of Sequential Iteration in Engineering Design'. *Management Science,* Vol. 43, No. 8, pp. 1104-1120.

Srinivasan, V., Lovejoy, W. S. and Beach, D. (1997), 'Integrated Product Design for Marketability and Manufacturing'. *Journal of Marketing Research,* Vol. 34, No. 1, pp. 154-163.

Stewart, D. V. (1981), 'The Design Structure System: A Method for Managing the Design of Complex Systems'. *IEEE Transactions on Engineering Management,* Vol. EM-28, No. 3, pp. 71-74.

Swink, M. L., Sandvig, C. J. and Mabert, V. A. (1996), 'Customizing Concurrent Engineering Processes: Five Case Studies'. *Journal of Product Innovation Management,* Vol. 13, No. 3, pp. 229-244.

T

Teresko, J. (1994), 'Service Now a Design Element'. *Industry Week,* Vol. 243, No. 3, pp. 51-52.

Terwiesch, C. and Loch, C. H. (1999), 'Measuring the Effectiveness of Overlapping Development Activities'. *Management Science,* Vol. 45, No. 4, pp. 455-465.

Tucker, F. G. (1983), 'Creative Customer Service Management'. *International Journal of Physical Distribution & Materials Management,* Vol. 13, No. 3, pp. 34-50.

U

Ulrich, K. T. (1995), 'The role of product architecture in the manufacturing firm'. *Research Policy,* Vol. 24, No. 3, pp. 419-440.

Ulrich, K. T. and Ellison, D. J. (1998), *Beyond Make-Buy: Internalization and Integration of Design and Production* (Working Paper). Philadelphia: Department of Operations and Information Management, The Wharton School.

Ulrich, K. T. and Ellison, D. J. (1999), 'Holistic Customer Requirements and the Design-Select Decision'. *Management Science,* Vol. 45, No. 5, pp. 641-658.

Ulrich, K. T. and Eppinger, S. D. (2000), *Product Design and Development.* (Second ed.). New York: McGraw-Hill.

Ulrich, K. T., Sartorius, D., Pearson, S. and Jakiela, M. (1993), 'Including the Value of Time in Design-for-Manufacturing Decision Making'. *Management Science,* Vol. 39, No. 4, pp. 429-447.

Utterback, J. M. (1994), *Mastering the Dynamics of Innovation.* Boston: Harvard Business School Press.

V

Van Bennekom, F. and Goffin, K. (2002), *Best Practices in Design for Supportability: Gaining Competitive Advantage from Customer Support.* Florida: AFSMI.

Voss, C., Tsikriktsis, N. and Frohlich, M. (2002), 'Case research in operations management'. *International Journal of Operations & Production Management,* Vol. 22, No. 2, pp. 195-219.

W

Wagner, W. B. and LaGarce, R. (1981), 'Customer Service as a Marketing Strategy'. *Industrial Marketing Management,* Vol. 10, No. 1, pp. 31-41.

Ward, A. C., Liker, J. K., Cristiano, J. J. and Sobek II, D. K. (1995), 'The Second Toyota Paradox: How Delaying Decisions Can Make Better Cars Faster'. *Sloan Management Review,* Vol. 36, No. 3, pp. 43-61.

Whitley, R. and Hessan, D. (1996), 'Customer-centred growth: five strategies for building competitive advantage'. *Managing Service Quality,* Vol. 6, No. 5, pp. 47-52.

Whitney, D. E. (1993), 'Nippondenso Co. Ltd: A Case Study of Strategic Product Design'. *Research in Engineering Design,* Vol. 5, No. 1, pp. 1-20.

Wise, R. and Baumgartner, P. (1999), 'Go Downstream'. *Harvard Business Review,* Vol. 77, No. 5, pp. 133-141.

Y

Yamamoto, M. and Lambert, D. R. (1994), 'The Impact of Product Aesthetics on the Evaluation of Industrial Products'. *Journal of Product Innovation Management,* Vol. 11, No. 4, pp. 309-324.

Yin, R. K. (1994), *Case Study Research.* (2nd ed.). California: Sage Publications.

APPENDIX 1. RESEARCH METHODS CONSIDERED

Method	Advantages	Disadvantages	Implications for my research
Action research	• Fundamentally about organisational change and improvement • Theory building and testing in action • More valid data collection (Project concurrently running with research. Researcher does not depend on recollections) • Detailed investigation. Involvement in all aspects of the product development process. • Direct access to all relevant documentation, people involved and meetings	• Longitudinal study • Limited cases. Products take generally more than a year to develop • Not easily generalisable results • Research context is industry specific • Researcher highly involved. Difficult to retain objectivity (separate the change agent role from the researcher role) • Assimilation by everyday routine	• Could be used for both research questions • Purpose of the research is to observe current processes and not to take action for change • Participation in meetings and decision checkpoints could give a valuable insight in order to aswer both research questions • Time framework does not allow for multiple products to be investigated, thus reducing the generalisability of the results
Case Study	• Describe and explain rather than measure. Appropriate for the exploratory nature of this research • Detailed, in-depth research about natural events and the way parts relate together • Recognise the complexity and embeddedness of social truths • More likely to produce more accurate reports about	• Provide little basis for scientific generalisation (Many cases allow for a degree of generalisation) • Might refer to past products/ processes (today things might be done differently, data might have been discarded) • Cannot in itself provide the whole picture • Take too long and might	• Case study could be used for all the Research Questions • For the documentation to be retrievable and the managers to be able to recall as many details as possible the research should investigate products no older than 10 years. • Efforts should be made to get as much depth as possible, for the exploration to be a more accurate representation. • Attention should be given on the issues of triangulation and the rigour/ validity of the work.

	everyday life • Are capable of offering some support to alternative interpretations	result in massive unreadable documents • Lack of rigour. Stories with no scientific grounding • Difficult access to companies	
Survey	• Broad sweep of a topic • Deals with large samples and so produces more generalisable findings • Investigates current processes and products • Easier access to sample through associations	• Not detailed investigation • Difficult to triangulate data • Difficult to get responses from managers from different departments at the same time • Bias in how questionnaires are worded in sample selection and in questionnaire completion • Statistical model may be too simple to capture the complexity of relations among variables	• Survey should be used after having explored the cases. This will help identify the most important issues to be included in the survey questionnaire

Table 49: Research methods, advantages, disadvantages and implications

APPENDIX 2. VALIDITY AND RELIABILITY CRITERIA FOR CASE STUDY RESEARCH

Criterion	Explanation	How the problem will be minimised in the research
Construct validity	Establishing correct operational measures for the concepts being studied	Many constructs have been previously tested and were adopted in the questionnaire used for data collection (e.g. serviceability from Goffin (1998)). Use multiple sources of evidence. Feedback will be given to the informants in order to establish the credibility of any interpretations A pilot study will be carried out at the Automotive Company.
Internal validity	Establishing a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships	Use of the explanation building method, suggested by Yin (1994). This method starts with the initial theoretical statement that when product support is involved in the design of a product, the quality of support provided in the field will be improved. Then, the findings from an initial case are compared against the statement and the statement is revised. The process continues with the findings from the next cases being compared against the revised statement as many times as is needed. Seek for negative evidence Consideration of rival explanations Feedback will be given to the informants in the form of writing-up, in order to establish the credibility of any interpretation by the researcher Multiple sources of evidence will help to provide data triangulation
External validity	Establishing the domain to which a study's findings can be generalised	Use of multiple cases will improve the external validity. Replication logic. Examination of possible threats to generalisability will take place.
Reliability	Demonstrating that the operations of a study can be repeated, with the same results	Use of the case study protocol, which contains the procedures and general rules that should be followed in conducting the research in different cases. Development of a case study database (a way to organise that data collected from the case) By comparing the issues across the sectors, further insights will be obtained.

Table 50: Measures of quality of case study research

INSTR1$_{PR}$

APPENDIX 3: PRODUCT REVIEW INTERVIEW

Interview questions:

1. What are the main characteristics of the products that we have here in front of us?
2. Could you identify one product that you think is easy and one that is difficult to support?
3. What are the key support characteristics of Product A?
4. What is different in product B in terms of support?
5. Why do you think those differences exist?
6. Do you think that the differences could be attributed to the design of the product?

Number	Support Aspect	Difference between the two products (Yes: ✓)	Manager's comments	Performance document to consult
1	Installation	[ ]		
2	Spare Parts	[ ]		
3	Maintenance	[ ]		
4	Repair	[ ]		
5	Upgrades	[ ]		
6	Usability	[ ]		
7	Warranty/ Cost of Ownership	[ ]		
8	Others (specify)	[ ]		

APPENDIX 4. CONTENT OF INTERVIEWS

Topics	Interviewees Position				
	R&D	**Support/ Service**	**Marketing**	**Manufacturing**	**Strategy**
Managers' perceptions for product support involvement during the New Product Development (NPD) processes	R&D managers' perception for product support involvement during the NPD process	Product support managers' perception for product support involvement during the NPD process	Marketing managers' perception for product support involvement during the NPD process	Manufacturing managers' perception for the product support involvement during the NPD process	Executive managers' perception for product support involvement during the NPD process
NPD Processes and product support involvement	NPD processes and product support involvement	NPD processes and product support involvement			
Product specifications	Product specifications	Product support input to product specifications			
Project control, prototype development, and the individual stages of NPD process for each product	Project control, prototype development, and the individual stages of NPD process for each product	Project control, prototype development, and the individual stages of NPD process for each product			
Product support Organisation – reports, attendance in NPD meetings, minutes, revenues, importance for the company	Organisation and Product support (reports, meeting, revenues)	Product support Organisation – reports, attendance in NPD meetings, minutes, revenues, importance for the company			Product support Organisation – reports, attendance in NPD meetings, minutes, revenues, importance for the company
Product support provision to customers		Product support provision to customers (which elements, methods, Design for Support) for each			

Quantitative design stage goals for support for each product Product's product support performance Target Markets for the two products, market shares Promotion of Product support Competitive analysis and product's attributes Design for Manufacturing for the two products Product Strategy for the two products Competitive advantage	Design for Manufacturing for the two products	product Quantitative design stage goals for support for each product Product's product support performance	Target Markets for the two products, market shares Promotion of Product support through advertisements Competitive analysis and product's attributes	Design for Manufacturing for the two products	Product Strategy for the two products Competitive advantage

Table 51: Managerial positions and content of the interview

INSTR1$_{MAN1}$[A/B]

APPENDIX 5: MANAGERIAL INSTRUMENT

1. Involvement in the current NPD process

Product development progresses through a series of stages, and customer support's involvement may differ across these stages. Please select the response that best characterizes **product support's involvement in each stage of the product development cycle.**

Product Development Stage	Among the Decision Makers	Influence Decision Makers	Provide Information for Decision Makers	Observer	No Involvement	N/A
Concept Development	❑	❑	❑	❑	❑	❑
Product Specification	❑	❑	❑	❑	❑	❑
Design / Development	❑	❑	❑	❑	❑	❑
Unit or Module Testing	❑	❑	❑	❑	❑	❑
System or Alpha Test	❑	❑	❑	❑	❑	❑
Beta or Field Test	❑	❑	❑	❑	❑	❑
Problem Classification & Resolution	❑	❑	❑	❑	❑	❑
Release Candidate Certification	❑	❑	❑	❑	❑	❑
Documentation	❑	❑	❑	❑	❑	❑
Post Release Problem Resolution & Product Improvement	❑	❑	❑	❑	❑	❑

2. Involvement in the NPD process of Product ....

Product development progresses through a series of stages, and customer support's involvement may differ across these stages. Please select the response that best characterizes **product support's involvement in each stage of the product development cycle.**

Product Development Stage	Among the Decision Makers	Influence Decision Makers	Provide Information for Decision Makers	Observer	No Involvement	N/A
Concept Development	❑	❑	❑	❑	❑	❑
Product Specification	❑	❑	❑	❑	❑	❑
Design / Development	❑	❑	❑	❑	❑	❑
Unit or Module Testing	❑	❑	❑	❑	❑	❑
System or Alpha Test	❑	❑	❑	❑	❑	❑
Beta or Field Test	❑	❑	❑	❑	❑	❑
Problem Classification & Resolution	❑	❑	❑	❑	❑	❑
Release Candidate Certification	❑	❑	❑	❑	❑	❑
Documentation	❑	❑	❑	❑	❑	❑
Post Release Problem Resolution & Product Improvement	❑	❑	❑	❑	❑	❑

3. Performance of product support for product ...

If you were to assess the performance of the product support elements for this product, what assessment would you give?

	Very Poor			Neutral			Excellent	
Installation	1	2	3	4	5	6	7	N/A
Customer training	1	2	3	4	5	6	7	N/A
Usability	1	2	3	4	5	6	7	N/A
Documentation requirements	1	2	3	4	5	6	7	N/A
Preventative maintenance methods	1	2	3	4	5	6	7	N/A
Reliability	1	2	3	4	5	6	7	N/A
Repair philosophy (e.g. diagnostics)	1	2	3	4	5	6	7	N/A
Spare parts requirements	1	2	3	4	5	6	7	N/A
Field organisation	1	2	3	4	5	6	7	N/A
Technical/Application advice service	1	2	3	4	5	6	7	N/A
Cost of ownership	1	2	3	4	5	6	7	N/A
Service profit	1	2	3	4	5	6	7	N/A
Online support provision	1	2	3	4	5	6	7	N/A
Upgradeability	1	2	3	4	5	6	7	N/A

4. Importance of product support to the customers

How important are these customer support elements to the users of this product?

	Not Important			Neutral			Very Important	
Installation	1	2	3	4	5	6	7	N/A
Customer training	1	2	3	4	5	6	7	N/A
Usability	1	2	3	4	5	6	7	N/A
Documentation requirements	1	2	3	4	5	6	7	N/A
Preventative maintenance methods	1	2	3	4	5	6	7	N/A
Reliability	1	2	3	4	5	6	7	N/A
Repair philosophy (e.g. diagnostics)	1	2	3	4	5	6	7	N/A
Spare parts requirements	1	2	3	4	5	6	7	N/A
Field organisation	1	2	3	4	5	6	7	N/A
Technical/Application advice service	1	2	3	4	5	6	7	N/A
Cost of ownership	1	2	3	4	5	6	7	N/A
Service cost	1	2	3	4	5	6	7	N/A
Online support provision	1	2	3	4	5	6	7	N/A
Upgradeability	1	2	3	4	5	6	7	N/A

INSTR1$_{MAN}2^{A/B}$

APPENDIX 6: PRODUCT SUPPORT TARGETS

Quantitative Design Stage Goals for Support.

ımber	Support Aspect	Relevant (Yes: ✓)	Design Stage Measure	Notes on use by Respondent's Company
1	Installation	[ ] [ ] [ ]	Time required (Human) resource / skill level Material / equipment required	
2	User training	[ ] [ ] [ ]	Time to train the user Trainer's skill level Documentation	
3	Maintenance	[ ] [ ] [ ] [ ] [ ]	Mean-time-between-maintenance Human resource Time per maintenance Material / equipment required	
4	Repair	[ ] [ ] [ ] [ ] [ ] [ ]	Failure rate Fault diagnosis time Mean-time-to-repair (MTTR) (Human) resource required Disassembly/ reassembly time Repair costs	
5	Upgrades	[ ] [ ] [ ]	Time required (Human) resource required Material /equipment required	
6	Usability	[ ]	Ease-of-operation	
7	Warranty/ Cost of Ownership	[ ]		
8	Others (specify)	[ ]	e.g. spare parts	

INSTR1$_{CUST}$1$^{A/B}$

APPENDIX 7: CUSTOMER INSTRUMENT

Which of those elements did the manufacturer offer to you and what was their performance?

	Very Poor			Neutral			Excellent	
Installation	1	2	3	4	5	6	7	N/A
Customer training	1	2	3	4	5	6	7	N/A
Usability	1	2	3	4	5	6	7	N/A
Documentation requirements	1	2	3	4	5	6	7	N/A
Preventative maintenance methods	1	2	3	4	5	6	7	N/A
Reliability	1	2	3	4	5	6	7	N/A
Repair philosophy (e.g. diagnostics)	1	2	3	4	5	6	7	N/A
Spare parts requirements	1	2	3	4	5	6	7	N/A
Field organisation	1	2	3	4	5	6	7	N/A
Technical/Application advice service	1	2	3	4	5	6	7	N/A
Cost of ownership	1	2	3	4	5	6	7	N/A
Service cost	1	2	3	4	5	6	7	N/A
Online support provision	1	2	3	4	5	6	7	N/A
Upgradeability	1	2	3	4	5	6	7	N/A

How important are these product support elements to you?

	Not Important			Neutral			Very Important	
Installation	1	2	3	4	5	6	7	N/A
Customer training	1	2	3	4	5	6	7	N/A
Usability	1	2	3	4	5	6	7	N/A
Documentation requirements	1	2	3	4	5	6	7	N/A
Preventative maintenance methods	1	2	3	4	5	6	7	N/A
Reliability	1	2	3	4	5	6	7	N/A
Repair philosophy (e.g. diagnostics)	1	2	3	4	5	6	7	N/A
Spare parts requirements	1	2	3	4	5	6	7	N/A
Field organisation	1	2	3	4	5	6	7	N/A
Technical/Application advice service	1	2	3	4	5	6	7	N/A
Cost of ownership	1	2	3	4	5	6	7	N/A
Service cost	1	2	3	4	5	6	7	N/A
Online support provision	1	2	3	4	5	6	7	N/A
Upgradeability	1	2	3	4	5	6	7	N/A

INSTR1$_{DOC3}$

APPENDIX 8: MASTER DOCUMENT LIST

MASTER DOCUMENT LIST	Company:	
	Product A	Product B
New Product Development		
NPD Process Map		
Stages, Gates, Actions, Selection (Proceed/Kill) Criteria		
Product Specification		
Variants of the Product		
Mission Statement for the product development project		
Product Plan (a diagram illustrating the timing of the planned products)		
Priority of development objectives		
Design Reviews		
Product Manuals/ Commercial documents		
Concurrent design documents (if used)		
Customer Support		
Technical support / Maintenance pricing		
Channels of service distribution		
Product pricing		
Document related to CS performance of the products (reliability, usability, training, repair, serviceability)		
Level of warranty cover		
Marketing		
Markets and offerings		
Customer wants / Customer needs/ Buying criteria		
Product Profile		
Competitive Analysis		
Market Research results		
Marketing Strategy for the product		
Advertisement / Promotion		
Customer preferences/ likes/ dislikes		
Launch Plans		
Manufacturing		
Prototype Development (Graphs, Charts, Phases, Inputs from functions, involvement of customers/ role)		
Role of Suppliers		
Top-Level Management		
Product Strategy		
Organisation of the NPD team		
Other Documents		
Sales and Service Report		
Minutes from Meetings		
Market Requirements Specification		

INSTR1$_{DOC}$4

APPENDIX 9: RECORDING PRO-FORMA FOR DOCUMENTS

NAME OF THE DOCUMENT:.....

DATE OF RELEASE:.....

AUTHOR(S):.....

NUMBER OF PAGES:.....

CUSTOMER SUPPORT ☐ NPD ☐

NOTES:.....

No	Issue	Text/Quote	Comments

INSTR1$_{DOC}$5

APPENDIX 10: PRO-FORMA FOR PERFORMANCE DATA RECORDING

ımber	Support Aspect	Metrics in place (Yes: ✓)	Name of measure	Reference document	Notes about the measure
1	Installation	[ ]			
2	Spare Parts	[ ]			
3	Maintenance	[ ]			
4	Repair	[ ]			
5	Upgrades	[ ]			
6	Usability	[ ]			
7	Warranty/ Cost of Ownership	[ ]			
8	Others (specify)	[ ]			