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CUSTOMER SUPPORT AND NEW PRODUCT DEVELOPMENT—AN EXPLORATORY STUDY

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BIOGRAPHICAL DETAILS

Keith R.H. Goffin is Professor of Innovation Management at Cranfield School of Management in the UK. He studied Physics at Durham University, graduating in 1977 with first class honours. Subsequently he obtained a MSc in Medical Physics from Aberdeen University in Scotland, specialising in developing software for the analysis of heart function. For fourteen years he worked in the electronics industry: as an engineer on new product development; managing customer support groups; and as a marketing manager. Parallel to his working responsibilities he studied for a Ph.D. at Cranfield School of Management, graduating in 1993. His research on customer support has practical applications that have been put to use at a number of companies. In 1995, Keith joined the teaching faculty of Cranfield, where he teaches operations management on MBA and executive programmes. His research interests are all focused on innovation, including product support for high-tech products and innovation rates in different industrial sectors. He has published widely, including articles in the *International Journal of Physical Distribution & Logistics Management, International Journal of Operations & Production Management,* and the *Journal of Product Innovation Management.*

Colin New was Professor of Manufacturing Strategy and Deputy Director of Cranfield School of Management until he took early retirement in 1999. He started his industrial career with Rolls-Royce Aero Engines in Derby, where he was involved in advanced production planning and control systems. He subsequently completed the Masters programme at London Business School with Distinction and then stayed on to teach at LBS for seven years before moving to Cranfield in 1978. He was appointed Deputy Director of the School with special responsibility for graduate programmes in June 1989. His research areas include manufacturing strategy; manufacturing planning and control; and distribution systems management and he developed the *Best Factory Awards* survey of manufacturing performance, which is now running in Germany, Italy and the UK. Colin is the author of three books and a large number of papers and articles on manufacturing strategy. On a number of occasions, Colin acted as a special advisor to the UK Government on the competitiveness of manufacturing industry. He has also acted as a consultant to many manufacturing companies across Europe and the United States. He is currently writing two books and several major research reports.

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ABSTRACT

Customer support is an essential element in the successful marketing of many products—from domestic appliances to high-tech computer networks. Many aspects of support are strongly influenced by a product's design and so customer support requirements should be evaluated during new product development. However, researchers have largely ignored the relationship between new product development and customer support. The current study addressed this gap by using case studies and a workshop, both conducted with leading companies, to identify how customer support is typically evaluated at the design stage and to determine the importance of this aspect of new product development. The results have implications for managers responsible for product innovation—they show the need to allocate adequate resources to integrating customer support requirements into new product development.

KEYWORDS

Customer support; new product development; design for supportability

INTRODUCTION

End-users of many types of product, ranging from computer systems to domestic appliances, require customer support at some time—assistance to help them gain maximum value from their purchases. Typical forms of support include installation, documentation, maintenance and repair services (generally termed *field service*), and

user training. In fact customer support entails all activities “to ensure that a product is available for trouble-free use to consumers over its useful life span” (Loomba, 1998).

Customer support, which is also referred to as *product support, after-sales service, technical support,* or simply *service,* is important for manufacturers because it:

- Is essential for achieving customer satisfaction and good long term relationships—as identified by a number of researchers (Armistead and Clark, 1992; Athaide *et al*, 1996; Cespedes, 1995; Christopher et al, 1991; Davidow, 1986; Lele and Sheth, 1987; Teresko, 1994).
- Can provide a competitive advantage (Armistead and Clark, 1992; Davidow, 1986; Goffin, 1998; Hull and Cox, 1994). This is true in most high-tech industries (Goffin, 1994; Lawless, and Fisher, 1990; Meldrum, 1995) but also in some low-tech sectors (Moriarty and Kosnik, 1989). As product differentiation becomes harder in many markets, companies are increasingly looking to customer support as a potential source of competitive advantage (Loomba, 1998). A number of examples of how companies have won market share through good support can be found in the trade press [see for example (Goffin, 1994)].
- Plays a role in increasing the success rate of new products (Cooper and Kleinschmidt, 1993);
- Needs to be fully evaluated during new product development (NPD), as good product design can make customer support more efficient and cost-effective (Armistead and Clark, 1992; Berg and Loeb, 1990; Cespedes, 1995; Goffin, 1998).

Although there is ample anecdotal evidence that customer support is an essential aspect in the marketing of many products, the relationship between customer support

requirements and NPD is not adequately understood. Therefore, exploratory research was conducted which had two main objectives:

- To investigate the role of after-sales support in five different sectors—covering both simple and complex products
- To investigate how different companies evaluate customer support requirements during new product development

The results show that customer support is highly important in a range of markets with vastly different products—from domestic appliances, to passenger aircraft. Additionally, the research shows the need to address support requirements at the design stage. The results have implications for all managers responsible for NPD, in any industry where support plays a significant role.

CUSTOMER SUPPORT

The Importance of Customer Support

As already explained, good customer support is a prerequisite for achieving customer satisfaction; it can increase the success rate of new products and directly contribute to competitive advantage. In addition, it can be a major source of revenue for manufacturers (Berg and Loeb, 1990; Hull and Cox, 1994; Knecht, et al 1993). In fact, the total worldwide market for high-tech support is estimated at $400 billion (Blumberg, 1992) and the importance of support revenues to manufacturing companies in a range of industries has been identified (Knecht, et al 1993). Over the working lifetime of a product, the support revenues from a customer may be far higher than the initial product revenue (ibid). Despite the importance of customer support as a source of both revenue and profit, it is an area that has often only received scant attention from managers (Knecht *et al*, 1993). Perhaps as a result of this lack of

management attention given to customer support, it has also failed to attract the attention of management researchers (Hull and Cox, 1994). This is in stark contrast to the amount of previous research on what is termed *customer service*.

Customer Support in Context

It is important to see understand how the topic of customer support relates to the extensive literature on customer service. Customer service—the way in which a customer is handled before, during and after the sales transaction (of either a tangible product or a service)—has been researched from both the operations management and marketing perspectives. Many papers and books have been published on this area, describing for example the differences between the marketing of services and products (e.g. Payne, 1993). Another highly researched area is the perceived quality of the service received by the customer, including the many studies using the well-known "Gap Model" (Zeithaml and Bitner, 1996). The streams of research into customer service are well established. In contrast, customer support—a specific type of customer service offered by manufacturers—has not been as highly researched. However, customer support is now "being recognised as an important research priority" (Loomba, 1996).

The majority of what has been written about customer support has been published for practitioners. Examples are journals, such as *AFSM International—The Professional Journal,* (the publication of a professional association for customer support managers), and books (e.g. Wellemin, 1984; Patton, 1984; Laub and Khandphur, 1996). An extensive review of the practitioner literature identified seven elements of support (Goffin, 1999).

The Elements of Customer Support

The seven key elements of customer support are:

- *Installation.* For many products, the first element of product support following the sale is installation. For complex products, or where safety issues are involved, personnel from the manufacturing company, or their representatives usually perform this.
- *User Training.* The complexity of some types of equipment means that manufacturers must provide good training for users. For example, the successful implementation of new manufacturing equipment often depends on extensive training (Athaide *et al*, 1996). Many products include functions, which help users learn to use them more efficiently; these can range from simple *Help* functions, to full computer training packages.
- *Documentation*. Most products require some form of documentation. Typical forms of documentation cover equipment operation, installation, maintenance and repair. Good documentation can reduce support costs (Miskie, 1989).
- *Maintenance and Repair.* Historically, this has always been an important element of customer support. Maintenance, is necessary to clean, refurbish or replace parts of equipment which otherwise would be liable to fail. If equipment fails, fast and efficient repair is essential in many markets because “down-time costs run typically at anywhere from 100 to 10,000 times the price of spare parts or service” (Knecht *et al*, 1993). Manufacturers need to have effective logistics for the management of *customer support engineers* and the movement of *spares*, the parts used in repairs.

- *On-Line Support.* Telephone advice on products is important in many industries. Product experts give on-line consulting to customers to help them use products more efficiently or, sometimes to trace the cause of faults.
- *Warranty.* Manufacturers' warranties reduce the financial risk of owning products. Over the working lifetime of a product, support costs can be high and so many manufacturers offer customers the possibility to purchase *extended warranty*.
- *Upgrades.* Customers may be offered the opportunity to enhance the performance of existing products. For example, computer upgrades increase the working lifetimes of products.

Over the last fifteen years there has been a change in the relative importance of different elements of customer support. In the past, when many products had high failure rates, the most important aspect of support was fast and reliable repair (Lele and Karmarker, 1983). New technologies have now typically led to more reliable products. However, increased product complexity (which is often software-based) means that the importance of user training and on-line support has increased (Goffin, 1998).

Previous Publications and Research

Table I shows that there are five aspects of the management of customer support on which papers and books have been published. Customer support strategy consist of writings on how support contributes both to the competitive advantage of companies, the achievement of customer satisfaction and the generation of revenues—there is often a difficult balance to be achieved between the latter two points. In recent years

there has been increasing recognition of the strategic importance of customer support to manufacturers (Knecht *et al*, 1993).

Insert Table 1

A key aspect of support is the management of the field support organisation—including the engineers who install and maintain equipment. Much has been written for practitioners on how to approach this and there has been some academic research into best practices (e.g. Hull and Cox, 1994). Just as the management of engineers is important, so is the logistics of spare parts. Inventory levels for spare parts are difficult to control and, for example, research has shown that the approaches used for stock control in manufacturing situations do not apply to spare parts (Fourtin and Martin, 1999).

Two emerging areas should also be mentioned. Customer support organisations have extensive knowledge of customers' requirements and this information is now being recognised as invaluable for marketing. However, little has been published on this area yet. Similarly, the relationship between new product development and customer support has been discussed by a number of authors but is not well understood.

Customer Support and NPD

Support revenues may be a significant source of income for manufacturers but for customers the cost of maintaining equipment over its working lifetime—referred to as *cost-of-ownership* (Taylor, 1995)—can be prohibitive. Therefore, customers in many sectors are demanding more economical and effective customer support (Loomba, 1996). A key factor which influences the efficiency and economics of customer

support is product design (Lele, 1986). However, the need to consider customer support during NPD has been largely ignored by both companies and researchers (Goffin, 1998).

A number of authors have recognised the importance of support requirements being considered at the design stage (e.g. Cespedes, 1995; Armistead and Clark, 1992; Berg and Loeb, 1990; Goffin, 1998). Product design influences both the amount of support necessary and the means by which it can be delivered (Garvin, 1988; Sleeter, 1991). For example, decisions taken at the design stage affect product reliability and consequently how often products require maintenance and repair (Lele, 1986). Similarly, a modular approach to product design can reduce repair costs (Hedge and Kubat, 1989), as can good diagnostics (Armistead and Clark, 1992; Karmarker and Kubat, 1987). However, beyond repair and maintenance, product design also influences the amount of user training which is necessary and the ease of upgrading products. Appropriate product design can therefore significantly reduce cost-of-ownership (Blanchard, 1991). For example, Microsoft's *Windows 95* product was "specifically designed to reduce total cost of ownership through increased ease of use, functionality and support" (Taylor, 1995). Products that have been consciously designed for easy customer support have a strong differentiating factor in the market (Swink, et al 1996).

It is important to not only consider customer support requirements early in NPD but also to make a comprehensive evaluation. The early evaluation of *all* aspects of product support at the design stage has been termed *Design for Supportability* (DFS-II) by Goffin (1998). To achieve this, it has been recognised that engineers with experience of customer support should be involved in product development (Hull and

Cox, 1994), as "by participating in the development stage, the after-sales group can add substantial value by making the equipment more 'maintenance-friendly'" (Knecht et al, 1993). However, a survey showed that customer support personnel were only "occasionally involved in new product work" (Page, 1993). In addition, research has shown that many companies do not consider product support until relatively late in the development cycle (Goffin, 1990). Low involvement of customer support personnel in NPD can lead to products that are difficult to repair and which have excessive warranty and service costs (Anthoney and McKay, 1992).

Design for Supportability Practices

Although the need to evaluate support requirements is recognised, information on how this should be done is sparse—only four articles discuss this aspect of NPD in detail (see Table II).

Insert Table II

Livingston describes how Rank-Xerox recognised that low cost-of-ownership is important to customers and that it can be minimised by reducing the cost of every aspect of support (Livingston, 1988). This recognition led to the adoption of a range of supportability goals including ease-of-use, ease-of-cleaning, easier maintenance procedures, and ease-of-repair. Rank-Xerox found that it was necessary to have a clear process for setting design priorities, as different functional departments may have opposing objectives. For example, manufacturing's objective may be to reduce assembly costs. This can lead to a product that is easy to manufacture but hard for engineers to repair at customer sites. A limitation of Livingston's article is that specific examples of the service/support goals are not given.

Teresko (1994) discusses *serviceability* (ease of product maintenance and repair) and product design, suggesting that "a new design idea is surfacing in the market battle for product supremacy: serviceability". A computer-aided design (CAD) tool is described which calculates field disassembly and re-assembly times and identifies service costs (Parker, 1993; Teresko, 1994). This package is based on earlier software used to ensure that products are easy to manufacture. The apparent limitation of the software is that it focuses on maintenance and repairs and ignores other important elements of customer support, such as user training, documentation, etc.

Hull and Cox (1994) conducted case study research at six leading electronics manufacturers. They focused mainly on field support organisations but also identified the importance of customer support engineers giving inputs to the NPD process. For example at National Cash Register (NCR), an information processing company, "maintainability and serviceability of products are a prime consideration in the design and manufacturing processes". Similar approaches were found at International Business Machines (IBM); Hewlett-Packard; General Electric (GE); and Amdahl (data processing systems). At American Telephone and Telegraph (AT&T) "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 by involving service engineers, Hull and Cox gave no information on how support is evaluated during NPD.

Previous research on hospital equipment (Goffin, 1998), identified three main points. Firstly, support requirements are typically not considered early enough during NPD. Secondly, support may have to "compete" for resources with issues such as

product features during NPD and so a clear understanding of the cost of support over the working lifetime of a product is required. Thirdly, it is important to provide quantitative design goals to R&D, related to each of the key support requirements. The main limitation of this research is that it only describes the approach taken at one company in detail.

The need for evaluating customer support during NPD is clear but previous research had the limitations, which were discussed. Therefore, the following research questions were identified:

1) What are the key elements of customer support in different industries? How are these related to the characteristics of typical products?
2) Is customer support important for both simple and complex products?
3) How do companies evaluate support requirements during new product development?

Overall, the investigation of NPD formed part of a wider study of customer support, which has been described previously (Goffin, 1999).

METHODLOGY

Research Design

As shown by the literature review, there has been only limited previous investigation of how customer support issues are evaluated during NPD. Therefore, the research was exploratory in nature and a suitable approach was required.

A postal survey of the issues was considered but rejected. Postal surveys have a number of limitations, including the possible ambiguity of questions, the lack of control over who actually answers the questionnaire and potentially low response rates (Moser and Kalton, 1971). Due to the complexity of some of the concepts of customer

support and their emerging nature, the possibility of ambiguous answers was considered to be high. Similarly, response rates for surveys in the field of customer support have previously been low (Goffin, 1998). Therefore, a case study approach was selected as an appropriate way to address the problems of non-response and ambiguous answers. However, in choosing case study methodology, the researchers recognised that the design needed to be carefully constructed to ensure sufficient rigour.

There are many issues to consider in achieving high-quality case study design but the main ones are construct validity and internal validity (Yin, 1994; Easton, 1995; Miles and Huberman, 1994). Construct validity refers to establishing suitable operational measures for the concepts being studied (Mason and Bramble, 1989). This was largely achieved by basing the questionnaire used for data collection on the work of previous researchers and sufficient piloting. Consequently, operational measures such as the percentage of revenues from customer support were identified from previous research. Internal validity refers to the reliability of a study and whether the variables chosen for investigation are sufficient to explain the topic under investigation (Dane, 1990). In order to maximise internal validity, multiple sources of data were used. For example, triangulation was used with informants' views being checked against company documentation where possible. Lincoln and Guba (1985) have identified observer bias as being a potentially real threat to reliable interpretation. To counter observer bias, "member checks"—feedback from informants—were used as the key method for establishing the credibility of an interpretation (Wallendorf and Belk, 1989). To achieve a rigorous case study design, the research was designed in four stages:

- *Preliminary contacts*. Leading companies in different industries were identified and contacted by letter. Their agreement to participate in the research was obtained and the manager responsible for customer support identified. At this point telephone calls were made to the customer support managers at each company to: explain the research aims; obtain a preliminary understanding of the role of customer support; set a date for a visit; and to identify the most suitable informants.
- *Case study visits.* One-day visits were made to the companies to conduct semi-structured interviews with the customer support manager and other informants, such as marketing and quality managers. During these visits the researcher also had the opportunity to inspect documentation and to view the company's products.
- *Data analysis and post-visit contacts.* After each visit, preliminary analysis and data reduction was conducted and, following the completion of all five visits, cross-case analysis was performed. There was also a high degree of involvement of the companies during this stage, in checking case descriptions and discussing the results with the researcher.
- *Workshop with participating companies.* The final stage of the research was a one-day workshop held with managers from the participating companies. This gave participating managers the opportunity to discuss the results of the cross-case analysis and best practices with managers from different sectors. At this workshop, the researchers obtained extensive feedback from managers.

Exploratory Sample

From the onset of the research it was clear that a single case study would not be sufficient. In exploratory studies single case are only appropriate if they are unique, extreme or revelatory (Yin, 1994). Therefore, five industries were selected as an

exploratory sample for the research. As the computer industry had been investigated previously (see Table II), it was decided to extend knowledge by focusing on sectors, which had not been studied before. Therefore, telecommunications, the car industry, vending machines, aircraft and domestic appliances were chosen—a purposive choice of industries. The choice was driven by the need to cover a variety of case study contexts. Therefore both a deliberately wide range of sectors (including both consumer and business-to-business products) and technologies (from electronics to mechanical devices) were included.

Once the industries had been chosen, "leading" companies were identified—companies having a significant market share in their industry. All of the sample companies have operations in Europe. As a motivation to participate in the research, companies were promised an informal "benchmarking report", contrasting their approach evaluating customer support during NPD to that of other companies. This offer was well received and only one company declined to co-operate with the research (forcing the selection of another company). In addition, participating companies were also told they would be invited to a workshop where the results of the research would be presented and discussed with the other companies.

Structure of Case Study Visits

The main data collection was performed during visits to the companies. These were made over a period of seven months in 1997-98. During each visit, semi-structured interviews were held with a range of informants. Holding on-site interviews at companies with personnel from various departments—typically customer support, marketing, quality, and development (see Table III)—allowed a comprehensive

picture of the role of customer support within the company to be obtained. Multiple informants also allowed data triangulation—an important approach to ensuring data reliability in manager-reported research (Miles and Huberman, 1994).

The interviews at each company were based on a questionnaire designed to collect information on each of the following areas:

- What are the characteristics of the company's typical products?
- What is the role of customer support in the company's market?
- What are the key elements of the customer support they offer to their customers?
- How are customer support requirements evaluated during new product development?
    - At what stage of NPD are requirements considered?
    - Which departments are responsible for evaluating support?
    - Are design goals set for support requirements?

Every interview was recorded (and later transcribed) and at the same time detailed notes were taken. Interview transcripts were prepared and footnotes added to explain any specific terms used by the respondents. Marginal notes were used to identify both key issues and areas where further clarification was required (this was obtained in the post-visit telephone calls). In addition to direct discussions, a number of telephone interviews were held with personnel who were not available during the on-site visits but interviewees had recommended the researcher to contact.

Where possible, a range of company documentation was inspected during the visits including:

- Company brochures and annual reports (for background information)
- Product brochures (to understand product features and to see whether customer support was used as a marketing tool)
- Financial statements (to investigate support revenues)
- Organisation charts (to see where customer support fitted in the structure of the company)
- Most importantly, documentation of how the evaluation of customer support fits into new product development.

Companies were willing to give the researcher copies of most of these documents but, in the case of financial statements and (sometimes) organisation charts, they only allowed inspection. After each visit a detailed case file was prepared containing the transcripts, interview notes and copies of documents.

Questionnaire Design

The 11-page questionnaire was based on the instruments developed by researchers who have previously investigated customer support; primarily the work of Goffin, (1990), Hull and Cox (1994); Knecht et al (1993); and Loomba (1996). Questions were incorporated on the importance of support; its key elements; product characteristics; and customer support and NPD. Due to the emergent nature of some of the issues involved, many of the questions were open-ended. [A copy of the questionnaire is available on request from the authors.]

Data Analysis

Case analysis was conducted in four main stages, which follows the recommendations of Miles and Huberman (1994):

- Each case was reviewed separately and the data analysed to give a complete picture of the company's approach to evaluating support at the design stage. The same data analysis framework was used for each case. To check the internal validity of the data, triangulation was used; between different respondents and between respondents' comments and copies of company documentation.
- Data reduction was performed and 2-3 page case descriptions were written on each company. A number of main headings were used for data presentation including *Product Characteristics; Key Elements of Customer Support; The Importance of Customer Support;* and *Customer Support and NPD.* The descriptions were then submitted to informants for two reasons. Firstly, informants checked that the case descriptions did not contain obvious clues to their company's identity or information that was likely to compromise their business. Secondly, informants checked the detail given in the case description—and a number of small corrections were made.
- Following this, cross-case comparisons were made, to determine where similarities and differences existed and to identify a number of "best practices" (Yin, 1994).
- As the results of the cross-case analysis were presented to participating companies during the workshop mentioned above, this allowed the conclusions to be discussed with the informants. The transcript of the recording of the workshop was also useful in this stage of the analysis.

RESULTS: FIVE CASE STUDIES

As the companies were promised anonymity, they will be referred to as *TelecommA, AutoB, VendorC, AeroD* and *DomesticE*. Information on each of these companies is

given in Table III, including company backgrounds, the informants interviewed and the key findings. In order to concentrate on the main results of the study, only short descriptions of each of the companies will be given (further within-case background information can be found in Goffin, 1999). This paper focuses on the cross-case analysis of the key elements of support and the way support is evaluated during NPD.

Insert Table III

Company and Product Overviews

TelecommA is a small company of 150 employees but they are the European leaders in the field of telecommunications systems. They design, integrate and support complex systems used in logistics applications, such as radio contact and control of fleets of vehicles. Systems consist of a central computer linked to devices such as PCs, sensors and radio equipment, with specialised software monitoring and controlling the resulting network. Each system sold has a unique configuration and costs are typically in the region of $1M. Customers—normally logistics companies and organisations—typically use their systems for up to 20 years and they are increasingly demanding more cost-effective support from TelecommA. Currently customer support, which is provided by the R&D group from the factory, only generates 4% of revenues but at margins, which are higher than those from product sales.

AutoB is a major international manufacturer of passenger cars, which has thousands of employees in its various organisations worldwide. They design, manufacture and market cars and their products are produced in very high volumes. Through their chain of dealers, they service cars in most countries A typical vehicle

produced by AutoB costs $15,000 and has a 10-12 year working lifetime, during which it will have a number of owners. Although customer support only accounts for 15% of AutoB's revenues, they acknowledge that it has a strong influence over whether customers make repeat purchases—the importance of customer support in the automotive market has also been recognised by researchers (e.g. Goffin, 1999).

VendorC designs, manufactures, sells and supports complex vending machines and are the market leader. They employ several thousand people in their development, manufacturing and service organisations worldwide. Vending companies buy large numbers of machines to provide self-service sales of a wide range of goods, some of high value. Modern vending machines—often referred to as *vending terminals*—are a complex mix of mechanical, electronic, security and display technologies and a top range model can cost in the region of $15,000. The machines have a working lifetime of about 10 years during which regular maintenance is required. Customer support is essential to VendorC, as correctly functioning equipment prevents loss of sales for vending companies. In addition, VendorC make over a third of their revenues form customer support activities and top management has focused significant resources on this area since recognising that good support can "dramatically improve... [customers'] business performance" [VendorC—Quality Manager].

AeroD designs, manufactures, sells and supports small passenger aircraft—termed *regional aircraft* in the industry. They have several thousand employees, including significant numbers in development and production. Regional aircraft is a very competitive industry and margins are often low because the cost of materials and vendor components can exceed 65% of sales price. Aircraft typically cost between $6M and $12M, depending on their size and configuration. Individual aircraft have a

working lifetime of at least 20 years and support consequently accounts for 20% of company revenues. Since “the in-service performance of aircraft, in terms of flight safety and reliability, is paramount” [AeroD—Engineering Manager], customer support is a key part of the business.

DomesticE, which is based in continental Europe, designs, manufactures, sells and maintains “white goods”—domestic appliances, such as washing machines. They have several thousand employees and operate in a highly competitive, price-sensitive market—shown by the fact that despite having a strong brand, DomesticE have not been able to increase their prices for the last ten years. Modern washing machines are a mix of mechanical, electro-mechanical and, increasingly, electronic components and a typical model will cost in the region of $300. Machines have a working lifetime of about 10 years in normal usage. Strategically, support is “a major strength and a competitive advantage” and a key source of profit for DomesticE. The company strongly promotes its customer support in all its sales and marketing activities— “our extensive After-Sales Service ensures each product produces a market-leading performance from day one onwards” (extract from a promotional brochure).

Key Elements of Customer Support

From the trade literature, seven elements of customer support were identified. The case study research showed that not all of the seven elements are of importance to every company and identified an eighth element which applies to some companies—Table III gives the key elements for each of the companies.

The simplest products studied were the appliances of DomesticE, for which four elements of customer support are key. Installation is simple and a not particularly important aspect of customer support. In the majority of cases the customer installs the

machine, or independently arranges for it to be carried out by a local tradesman. However, simple and effective documentation is important because users seldom have much technical knowledge. DomesticE have recognised this and try to produce user documentation covering installation, operation and simple fault-finding which is deliberately written in a style that is accessible to typical users. Washing machines used to need preventive maintenance, for example replacement of the brushes on electric motors. However, maintenance has now been "engineered out of products by designing them for the whole life cycle" [DomesticE—Process Manager] and service engineers are not required unless a product fails. Quick response in the event of breakdowns is essential in this market and DomesticE have their own, long-established and extensive service organisation, assisted by call centres which try to solve problems over the telephone. Product warranty is important to DomesticE—one year is the industry norm but they differentiate themselves by offering the customer better terms.

In strong contrast to domestic appliances, the most complex products in the sample were aircraft and every element of customer support was both relevant and important for the manufacturer AeroD. This company delivers aircraft to their customers and conduct training of airline personnel, which is one of the most time-consuming aspects of support—both induction and refresher courses for airlines' pilots and maintenance engineers are run on a regular basis. As might be expected in a highly regulated industry, high quality documentation is essential and, in some cases, this must be approved. Key documentation includes the *flight manual*, which contains all the information that the pilot needs to operate the aircraft safely; and maintenance manuals. Depending on the level of usage (i.e. flying hours), a significant amount of

maintenance is required—something under 3 maintenance hours per flying hour is typical in the industry. AeroD sells spare parts to airlines for repair and maintenance purposes and they have a large call centre to give advice on maintenance issues. Warranty cover is comprehensive and generally specified for each major component of the aircraft. For example, engine and structural warranty are separately specified, in cycles (e.g. the number of take-offs and landings) or flying hours. Upgrading aircraft is also a significant business for AeroD. A key aspect of AeroD's strategy is their *engineering support*—advice to airlines on how best to manage their aircraft—which goes beyond the scope of support provided by response centres. Engineering support is provided without charge to major customers and helps increase aircraft reliability and prevent flight cancellations (which can lead to a major loss of revenues for airlines). "We [the manufacturer] can offer to examine the customer's operation and provide advice on how he can get the best from the product. This can be technical, operational or commercial advice" [AeroD—Customer Service Manager].

In terms of complexity, the products of the three other sample companies lie in different positions between the extremes, with cars and vending machines both being more complex than domestic appliances but simpler than telecommunications systems and aircraft. In the automotive industry product support is generally referred to as service and the four main elements are maintenance and repair including parts; documentation (workshop and owner manuals); the training of mechanics from recognised dealerships; and warranty. Due to their mechanical parts, cars require a significant amount of maintenance and repair and this increases cost-of-ownership. Stocking and distributing spare parts is a major business for AutoB. Warranty is

normally 12 months, although competitive pressure is changing this to 3 years in some countries.

VendorC manage all aspects of installation, from site surveying, to wiring and fitting. Training of the staff of vending companies who are responsible for first-line maintenance and replenishing machines plays a key role. Terminals have full technical documentation for maintenance purposes and some of this is being made available over the Internet. Timely maintenance and repair is very important as equipment downtime leads to lost sales. Consequently VendorC has invested heavily in establishing an effective support organisation. Warranties are 90 days—standard in this industry. In addition, VendorC sell upgrades on "used terminals to extend equipment lifetime" [VendorC brochure]. VendorC have the capability to offer full *goods management* to their customers—ensuring that machines are working and are replenished in a timely fashion. This new service is now an important source of revenue for VendorC and arose from customer feedback obtained by the field service function.

TelecommA's systems are complex and require extensive support, although the company has not focused on developing this side of the business. R&D engineers install systems and this typically takes 9 days. Systems are designed for ease of use but users still require training—typically one day following installation (TelecommA "spend very little time on training, we do try to pass that on to the customer" [TelecommA—Development Manager]). Hardware is very reliable and failure rates are typically only 1%. However, due to the complexity of networks, software problems may occur and require investigation. System documentation is produced by R&D engineers and some customers are now requesting comprehensive

documentation for their own use in first-line maintenance. All systems are sold with a 12 months hardware warranty and 3 months software warranty, which is standard in this industry. Upgrades, which enhance system capability, are a significant business for TelecommA and systems typically have a major upgrade every 2 years.

Across the sample of companies studied, it can be seen that different products have different key elements of customer support. Generally, more complex products require more aspects of customer support. It is the evaluation of the relevant aspects of customer support at the design stage that potentially can make support easier and more cost-effective.

New Product Development and Customer Support

Although customer support plays an important role for all of the companies, there was a wide variation in the approaches taken to integrating it into NPD. A key issue that emerged from the research was how "comprehensive" the evaluation of customer support requirements at the design stage is. For example, are all relevant elements considered early in the design cycle and are suitable design goals set for each of them? In this section of the analysis, the case results will be presented starting with the simplest approach to evaluating customer support during NPD.

The least comprehensive approach to the evaluation of customer support needs at the design stage was at TelecommA—as might be expected at a small company. For them, NPD involves taking a "core" computer system and integrating it with other devices to match specific customer needs and developing suitable software. The design of a system typically takes 6 months. Support issues are considered from the design stage but in an informal way: "our whole design ethos is to make it as simple to

maintain and support as possible. There's no formal documentation [on customer support requirements]" [Quality Manager]. TelecommA have no *product support plan* [a document that summarises the key issues of customer support for a particular product, which is common in the computer industry]. Many of TelecommA's R&D engineers have had experience of supporting previous systems in the field and are aware of customer support issues. However, no formal product design goals are set on any issues related to supportability. Consequently, there are currently no goals at TelecommA to reduce installation times, simplify training or minimise upgrade times and therefore reduce costs on new products.

DomesticE's product life cycles are normally 12 years but models "undergo a constant evolution of cosmetic and other design improvements over the life cycle" [NPD Process Manager]. New appliances are developed typically over 30 months by a cross-functional team including R&D, marketing, manufacturing, and suppliers. Product requirements are comprehensively documented at the design stage and a number of formal tools, such as Quality Function Development (QFD) and Design for Assembly (DFA), are used to help guide design decisions. Representatives from the service organisation have always been invited to give their inputs on new designs and prototypes. However, DomesticE are concerned that this has not worked efficiently—"we still need to get more service involvement and to have them take a more active part in the formal review process" [DomesticE—Process Manager]. Due to the number of mechanical components they contain, washing machines are susceptible to failure and the average failure rate is 25% for a machine in its first year of usage. Consequently, the analysis of customer support issues at the design stage focuses on two points—product reliability and ease of repair. For both of these, quantitative goals

are set at the design stage. However, no model of total lifetime service costs is currently used. DomesticE now face a number of challenges including the need to improve product reliability and ensuring that new, more complex products are easier to use.

Although their products are complex, AeroD do not set as many support-related design goals as, for example AutoB or VendorC. During development, the AeroD project team takes into account the requirements of a range of users making up what is called the *Advisory Group*; this includes pilots, cabin personnel, airlines' financial representatives and maintenance engineers. Accounting for the requirements of these different parties is not simple and the design group has to make decisions on the best solution to complex and sometimes opposing requirements. "One of the concerns is to make the aircraft cheaper to maintain" [AeroD—Design Manager] and a *Maintenance Steering Group* is used to identify the key requirements of maintenance personnel. They determine "some top level goals, like maintenance hours per flying hour" [AeroD—Design Manager] but not all aspects of support are currently evaluated in detail or have associated quantitative design goals. "I think its fair to say that many of these types of issues [design for easy maintenance] were again down to the experience of the team who were working on the job and the guidance of the more senior managers" [AeroD—Customer Service Manager]. With the high level of bought-in components, AeroD also have the issue that some aspects of maintenance are strongly influenced by their suppliers. Support has always been considered during NPD by the experienced design team but AeroD are now trying to improve this evaluation by determining a more comprehensive range of maintenance-related design goals.

Since three years, AutoB has had a specific organisation of 30 people with the responsibility for ensuring that customer support issues are adequately considered during NPD. Their charter "is to participate early and pro-actively in the new model development process and to represent customer services division in design decisions". [AutoB—Advanced Service Manager]. This is important because cost-of-ownership is a key factor in business-to-business sales, as fleet managers are acutely aware of vehicle running costs (comparisons of these are often published in trade journals). As a consequence, AutoB conducts a detailed analysis of the way every new product will be serviced. The product design goals which are set include *cost-of-ownership; serviceability;* and *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 analyses are summarised in a document called the *Cost of Ownership/Serviceability/Damageability Plan*, which assesses the five issues mentioned, for each and every major component in a car (an example copy of this plan was given to the researchers). As a consequence, design goals are set for both AutoB's development teams and suppliers. To convince the various departments involved in NPD to give suitable priority to service-related issues, a financial model is also used. This can "demonstrate the wisdom of reducing cost-of-ownership and look at the effect of poor repair capability on customer satisfaction... trying to put a dollar figure on it" [AutoB—Advanced Service Manager]. For the future, AutoB say they need to reduce cost-of-ownership further and are looking closely at the performance of their competitors in this area.

Of the five companies studied, VendorC make the most comprehensive evaluation of customer support at the design stage. Their NPD team is cross-functional and includes R&D, product management, manufacturing, suppliers and product support specialists. Their work is co-ordinated by a seven stage *Phase Review* plan, which specifies the key responsibilities of each department at each stage of NPD. Over the last five years, a strong focus on product support by management has led to the consideration of service issues being "pushed further back into the design", through the direct involvement of customer support specialists [VendorC—Field Service Engineer]. Consequently, the preparation of a *Product & Solutions Services Planning* document which summarises these issues is now an integral part of NPD. At the design stage product support specialists analyse the *RASUI* of products—the *reliability; availability; serviceability; usability*; and *installability*. For each of these five categories a detailed analysis is performed, and clear design goals are set. The Quality Department has the overall responsibility of ensuring that *RASUI* goals are met. In order to meet their challenging maintenance goals, VendorC have adopted a variety of approaches. These include modular design, for quick replacement of faulty or worn components, is standard practice and "diagnostic capability is designed into each individual element of terminals" [VendorC—Quality Assurance Engineer]. Several of the benefits to customers of the *RASUI* evaluation are clearly identified in product brochures. The performance of their installed base of vending machines is very closely monitored by VendorC's elaborate internet-based system, which collates data on all aspects of field service. Product reliability (e.g. downtime by product; by location; by cause; etc.) and service engineer efficiency (installation times; percentage first-time-fixes; etc.) are just two of the metrics which are reported daily by the field

organisation. Comprehensive data have been found crucial for early recognition of product problems and in setting design goals for new products.

DISCUSSION

The cases cover five very different markets but it can be seen that customer support plays an important role in each of them—managers identified that good product support plays a key role in both creating a competitive advantage and, in most cases, generating significant revenues. However, the cross-case analysis identified some key differences in:

- The elements of customer support which are important for particular types of products and
- How comprehensively companies evaluate customer support requirements at the design stage.

The nature and reliability of equipment obviously has a large influence over the key elements of product support. In the two companies where products have a large number of mechanical components, products require higher levels of maintenance. In the telecommunications industry hardware maintenance is less of an issue but in all five markets customers expect reliable products and quick response in the event of failure. Equipment retrofits or upgrades are an important element of customer support in three industries: telecommunications, vending machines and aircraft. Currently they are not important in the car industry but it remains to be seen whether this will change as more electronics systems are used in cars (a technology that lends itself to comparatively easy upgrades). Both VendorC and AeroD offer their customers an extra support service—goods management and engineering support

respectively. These services are more complex than the normal advice offered by call centres and appear to give a competitive advantage to the respective manufacturers. Further investigation is, however, required on the link between these new types of customer support and competitive advantage.

The degree with which customer support issues are evaluated at the design stage varied across the five companies. TelecommA, probably because of its small size, has the least formal approach. Although R&D engineers are used as a resource for field service and therefore often have first-hand knowledge of the problems, it appears that TelecommA could benefit from a more structured approach. For example, they have not set design goals to reduce installation times (and costs) from current levels. DomesticE and AeroD evaluate support at the design stage but do not use a full range of quantitative goals and both companies are not satisfied with the degree to which support requirements are input to their NPD programmes. They feel that too much still depends on whether R&D engineers have the experience to know how to design products which are easy to support. In contrast, both AutoB and VendorC make a comprehensive evaluation of every aspect of support and set design goals related to each of them. In addition, the supportability of previous generations of products is used as a benchmark—both companies want the customer support of each new product to be more efficient. VendorC's RASUI evaluation and tracking of a wide range of field service data appears to be useful mechanisms for ensuring that the needs of customer support are fully integrated into NPD. The strong support of top management the customer support function at VendorC is also acknowledged as being instrumental in their success.

From both the literature and the current study, the concept emerged of a *comprehensive* evaluation of customer support requirements at the design stage. The case companies appeared to have reached different levels of sophistication in this area. Although strict historical data on when the companies enhanced their approaches were not collected, discussions with informants indicated that this had taken some time—for example AutoB had assigned a specific group to the task for the last three years but still saw room for improvement. Reviewing the data on each of the case companies allowed a conceptual model, Figure 1, to be drawn. This illustrates the degree to which the companies evaluate support and how, over time, increased emphasis is put on this area.

Insert Figure 1

Initially, customer support requirements may not be recognised as important. Companies at Stage 1 do not recognise the potential of support business. And consequently do not evaluate it at the design stage. Poor product design means higher repair costs and can lead to dissatisfied customers. At Stage 2, companies consider reliability and repair times at the design stage and typically set quantitative goals for product reliability (mean-time-between-failures, MTBF) and ease-of-repair (mean-time-to-repair, MTTR). However, broader aspects of support are not considered at the design stage. Further progression leads to Stage 3, where companies involve panels of field engineers in NPD reviews. It is essential to evaluate all aspects of support at the design stage i.e. installation times; fault diagnosis times; field access times; repair times/costs, user training times; upgrade times; etc. Integrating this effectively into the NPD process may be difficult and so it may take companies a long time to reach Stage

4. At Stage 4 companies set quantitative goals at the design stage for all relevant aspects of support and use lifetime cost models. These goals push development engineers to develop designs that are easier and cheaper to support than previous products. Finally, leading companies may reach Stage 5, which is characterised by all of the issues considered at Stage 4 with two important additions. Firstly, financial reporting mechanisms are used to ensure that return on DFS investment is clearly visible to management. Secondly, the companies that reach Stage 5 have management teams that fully recognise the importance of support to their businesses and consequently devote sufficient focus and resources to this area. The position of each of the sample companies on Figure 1 was initially determined by reviewing their approach to evaluating customer support during NPD (as described in the text and summarised in Table III) and then verifying this with the companies directly.

The workshop, which was run with participating companies, enabled a verification of where the companies were positioned on the model. For example, VendorC confirmed that that they had an advanced approach. “I think we are at Stage 4… we [customer support specialists] are fully allocated to the teams… the quantitative analysis of cost… we basically do that but we are certainly [not] yet at 5” [consensus between the VendorC Quality Manager and Support Specialist]. VendorC are currently trying to further improve their design for Supportability practices, as indicated by the arrow moving to Stage 5 on Figure1. For AutoB, they are also improving “but not enough for me to convincingly say we are at Stage 4 [yet]” [AutoB—Product Support Specialist]. Overall, Figure 1 was found at the workshop to be an effective tool for discussions on the progress companies have made towards fully evaluating support requirements, however, it is still preliminary and obviously

needs further empirical verification. (This should include an estimation of the time required for companies to move between the various stages.)

STUDY LIMITATIONS AND FUTURE RESEARCH

The research described in this paper has limitations, which must be acknowledged—both in terms of the scope of the issues studied and the methodology used.

The number of aspects of customer support and NPD investigated was limited. 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 Design for Supportability would make new products easier to support and consequently reduce cost-of-ownership and in several cases had anecdotal evidence. However, this point needs further investigation and can be formulated into the following proposition:

> **Proposition 1:** *Products, which are developed after a comprehensive evaluation of customer support requirements has been made, will be easier and cheaper to support than comparable products where this is not the case.*

Although a detailed evaluation of support requirements at the design stage may improve the supportability of products, small organisations such as TelecommA may not necessarily need to implement a formal planning process. This would, of course, need to be considered in any research designed to check Proposition 1.

With the small sample of the current study, external validity is an issue. For example, results from the five companies indicate that more complex products require more elements of support. However, these results are inconclusive. More investigation is required of the following proposition:

> **Proposition 2:** *Manufacturers of more complex products must provide more elements of customer support than are required for simpler products.*

One of the key methodological limitations is that much of the data collected was "manager reported", although triangulation was used where possible. Researchers in the future will need to address this issue. For example, longitudinal studies in which

researchers are present at key design meetings and actually observe the process of evaluation and implementation of customer support requirements are needed.

For researchers active in the area of new product development, there are a number of other areas, which require further investigation. Research is necessary to identify whether the case companies manage customer support at the design stage in a way that is typical for their industry or whether, in addition to having large market shares, the sample can be considered as being “best-in-class” in this area. To establish this, a wide survey of companies’ practices is required, ideally covering several industries. The case on VendorC clearly demonstrates the competitive advantage that can be obtained from well-planned support and functionality in products, which supports incremental services. This requires further investigation—are a high percentage of manufacturing companies using support to gain a competitive advantage?

CONCLUSIONS

The contribution of this research is that it provided the first empirical evidence on how support is evaluated during NPD in different industries. It showed that leading companies invest significant resources to ensure that products are easy and economical to support. Previous research (Goffin, 1990) showed that many companies do not evaluate customer support until well into the NPD cycle. The current results show that the sample companies do not make this mistake—they all evaluate support at the design stage, albeit to varying degrees of sophistication.

The research has important implications for all managers involved with new product development and, in particular top management who can exercise the greatest influence. Although the sample size was small, certain best practices can be identified:

- Closely involving customer support experts in NPD.
- Performing a comprehensive evaluation of support needs at the design stage and setting suitable design goals.
- Using data management systems to monitor all aspects of field support.
- Having top management that recognises the importance of customer support at.
- Using customer support to gain a competitive advantage and increase revenues.

It has clearly been shown that customer support must be given a high enough priority during NPD. If they are not already doing so, manufacturing companies need to focus enough time and resources on this area. Overall, the evaluation of customer support needs to be recognised as an essential aspect of new product development.

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Figure 1: A Conceptual Model of the Stages in the Development of a Design for Supportability Approach during New Product Development (based on case study and workshop data). The arrows next to the company name indicate if they there are currently making improvements.

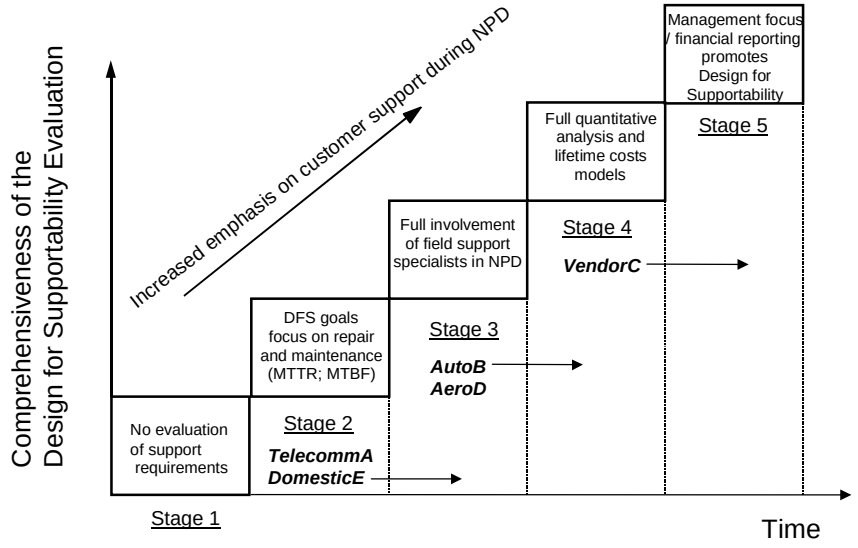

Table I: Summary of Key Previous Publications on Customer Support.

	Area	Example Publication(s)	Key Points from Publications
1.	Customer Support Strategy	Armistead and Clark, Knecht et al, 1993 Wellemin, 1984	Customer support can lead to competitive advantage Support needs to balance the generation of revenues against the achievement of customer satisfaction
2.	Organisation of Field Support	Armistead and Clark, 1992 Bleuel and Patton, 1986 Hull and Cox, 1994 Laub and Khandphur, 1996 Loomba , 1996 and 1998 Stone and Wild, 1985	Creating an efficient organisation for the delivery of support is essential Manufacturers may choose to create their own support organisations or use alternative channels, such as dealers
3.	Parts Logistics	Fourtin and Martin, 1999 Little et al, 1988 Patton, 1984	Supplying spare parts can be a highly profitable business Spare parts inventory control is complex because of the trade-offs necessary between part availability for slow moving parts
4.	Knowledge Management	Davenport and Klahr, 1998	A new area; support organisations have important knowledge of customers' requirements which is of high value to marketing
5.	NPD and Customer Support	Goffin 1998, Hull and Cox, 1994 Livingston, 1988 Teresko, 1994	The key points are described in detail in Table II

Table II: Summary of Previous Publications Giving Details of How Companies Evaluate Support During NPD.

Article	Industry(s)	Type of Article	Sample	Key Points
Livingston, 1988	Photo-copiers	Conference presentation on design for supportability.	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.
Teresko, 1994	Electronics, automobiles and plant equipment	Trade journal description of software for design for serviceability developed with a consortium of companies.	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.
Hull and Cox, 1994	Electronics and computing	In-depth case studies. Purposive sample of six companies. Main focus on field support but mentions design for supportability issues.	Amdahl AT&T Hewlett-Packard GE IBM NCR	"Leading" companies consider support during NPD. For example: At IBM "field service personnel... perform an important role as serviceability advocates" At NCR "maintainability and serviceability of products are a prime consideration in the design and manufacturing processes"
Goffin, 1998	Medical electronics	Survey of design for supportability at high-tech companies / Single case study.	Trade association / Hewlett-Packard	At many companies support is not considered until well into NPD Importance of understanding the support costs over the whole working lifetime of a product Key role of support-related design goals.

Company	*TelecommA*	*AutoB*	*VendorC*	*AeroD*	*DomesticE*
BACKGROUND					
Main Products (cost of typical product)	Telecommunications systems (cost: $1M)	All types of passenger cars (cost: $15,000)	Vending systems (cost: $15,000)	Regional passenger aircraft (cost: $9M)	Domestic washing machines (cost: $300)
Product Lifetimes	20 years	10-12 years	10 years (shorter in US)	20 years or more	10 years
No. of Employees	approx. 150	Many 1000s	several 1000	several 1000	several 1000
Main Interviewees	Development Manager Quality manager Operations Manager	Advanced Service Manager 4 Product Support (Factory) Specialists Financial Analyst	Quality Manager R&D Engineer Quality Engineer Support Specialist Field Service Engineer	Chief Design Engineer Customer Service Manager Engineering Manager	New Product Development Process Manager Design consultant
Role of Customer Support	"becoming more and more important"	Support "makes a difference to repeat sales"	Key to improving customers' own business performance	Crucial to ensure safety and to reduce cost-of-ownership	Service is "a major strength" and a competitive advantage.
Customer Support Revenues	4% of revenues (at 60% margins)	15% of revenues (25% of profits)	35% of revenues (at 25% margins)	20% of revenues (15% of profits)	"High" revenues[1] ("high percentage" of profits)
KEY RESULTS					
Key Elements of Customer Support	-Installation -Documentation -Fast problem resolution -Warranty -Upgrades	 -Dealer training (service) -Documentation -Spare parts -Warranty	-Full installation service -Training staff -Documentation -Maintenance & repair -Warranty -Refurbishment -Goods management	-Aircraft delivery -Training: pilots & engineers -Documentation -Spare parts supply -Call Centre -Warranty -Aircraft enhancements -Fleet management advice	 -User documentation -Repair -Call Centres -Warranty
NPD Cycle	6 months	3 years	18 months	3-4 years	30 months
Customer Support and NPD	Importance of easy support is recognised but evaluation at the design stage is not formalised. No documentation.	Dedicated group with charter to ensure products have high serviceability. Formalised processes and documentation.	Strong emphasis from top management on good and economical support. Formalised processes and full documentation.	Support is considered from the design stage. What was largely an informal process has been highly developed in the past few years.	Service issues considered by the design team from the concept stage. Inputs from the service organisation.
Use of Quantitative Design Goals	Very limited.	Extensive use of goals on many aspects of supportability.	*RASUI* goals set at the design stage for all aspects of support (see text).	"Some top level goals, like maintenance hours per flying hour" but not for all aspects of support.	Limited use of quantitative measures for reliability and ease-of-repair.

[1]The exact figure is confidential

Table III: Summary of Customer Support and NPD at the Five Case Companies.

Customer support and new product development : An exploratory study

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