The Role of Design in Product-Service Organisations

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Abstract

Amid claims that we live in a service economy, the distinction between manufacturing and services is blurred. Many manufacturers have made a product-service transition, whereby services are integrated with products, to meet demand for access to the benefits, but not the risks of ownership of products. Many aspects of this transition and the product-service offerings which result require investigation, principally the relationship with design. Design itself is a concept open to many interpretations and studies of it have been hampered by the lack of an accepted theoretical framework.

This research makes three main contributions, firstly it develops a theoretical framework for studying design and comparing organisations based on a proposed classification of design activities. Next it investigates the implications of a product-service transition, to add a three stage model of product-service development to the theoretical framework. Finally it uses the theoretical framework to explore the role of design in a large, product-service organisation and compares the findings to literature to position the theoretical contributions.

The research follows an abductive strategy, moving back and forth between the theoretical and empirical domains. The overall research topic is reduced to three sub-topics, allowing three sets of research questions to be investigated. Studies of design, product-service implications and the role of design in product-service organisations are presented, utilising literature reviews and qualitative case studies.

The research argues that design capabilities enable a product-service transition but a reconfiguration of design capabilities may be required as products are designed for multiple customers. Meanwhile, the customer-facing units described in the literature were found to act as a buffer, shielding designers from customer pressures and integrating customer requirements. For managers, this research highlights the considerations and implications of a product-service transition, while it has contributed articles to the academic literature and raises further research topics.

Publications

Journal Articles

- Candi, M, **Beltagui A**, Riedel, JCKH (forthcoming) "Innovation through experience staging" *accepted for publication in Journal of Product Innovation Management.*
- Pawar, KS, **Beltagui, A**, Riedel, JCKH (2009) "PSO triangle: designing product, service and organisation to create value" *International Journal of Operations & Production Management*, Vol.29, No.5, pp.468-493.
- Moultrie, J, Livesey, F, Malvido, C, **Beltagui, A**, Pawar, K, Riedel, J (2009) "Design Funding in Firms: A Conceptual Model of the Role of Design in Industry", *Design Management Journal,* Vol.4, No.1, pp.68-82.

Conference Papers

2011

- **Beltagui, A**, Candi, M, Riedel, JCKH (2011) Developing a scale to measure customer experience, to be presented at 18th International Product Development Management Conference (IPDMC 2011), Delft, The Netherlands, 5-7 June.

2010

- Riedel, JCKH, **Beltagui, A**, Candi, M (2010) Experience-Based innovation: a typology of experience staging strategies, at 16th International Conference on Concurrent Enterprising (ICE 2010), Lugano, Switzerland, June 21-23.

- **Beltagui, A**, Candi, M, Riedel, JCKH (2010) Experience-Based innovation as a means to success in New Product Development, at 17th International Product Development Management Conference (IPDMC 2010), Murcia, Spain, 13-15 June.

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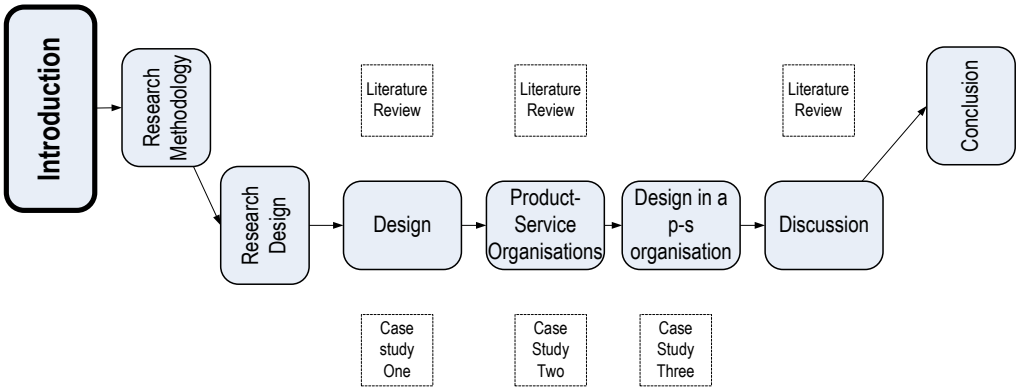
Contents

Chapter 1
Introduction

> *"…to survive in developed economies it is widely assumed that manufacturing firms can rarely remain as pure manufacturing firms. Instead they have to move beyond manufacturing and offer services and solutions, delivered through their products."*
>
> (Neely, 2007)

In recent years it has been claimed that we live in a service economy, or that manufacturing should be complemented or replaced by services. Companies are advised to make a transition to services or product-service offerings, which are seen as offering a win-win scenario for all involved. The role of design in making these transitions and developing these offerings will be investigated in this research. This chapter introduces the research by presenting the background to the study. It explains the research problem, the aims, objectives and contribution of the research.



This chapter introduces the research project, describing the research problem and how it will be addressed. Firstly, it introduces the concept of a product-service transition and the argument that we are now in a 'service economy' where the traditional importance of products has diminished. Next it describes the claim that the distinction between manufacturing and services is not so distinct, before describing the arguments that companies should make a product-service transition, which will be the focus of attention in this research. This concept of a transition from products to services, from selling ownership to offering access, is described, before an example is provided which demonstrates that this transition often involves design implications, which the literature does not necessarily capture. The chapter ends by stating the aims, objectives and research questions, along with a description of the proposed contribution to knowledge to be made by this research.

1.1 The service economy

A commonly encountered distinction is the one which separates "manufacturing" and "services" industries. In the industrial revolution, the former may have been considered the most important source of economic growth and development. For some time, however, statistics have shown service industries as the largest source of employment and largest contributors of wealth in the 'developed' nations. For example, in the UK services account for over half of Gross Domestic Product, while manufacturing's share continues to fall as shown in figure 1.1. In the USA, services now account for over 80% of employment (Chase and Apte, 2007). Since most employees work in service industries, most graduates are likely to find careers in these industries, yet it has been observed that

> *"management practice, accounting conventions, business school courses and public policies continue to suffer from an acute industrial age hangover"*
>
> (Henkoff, 1994)

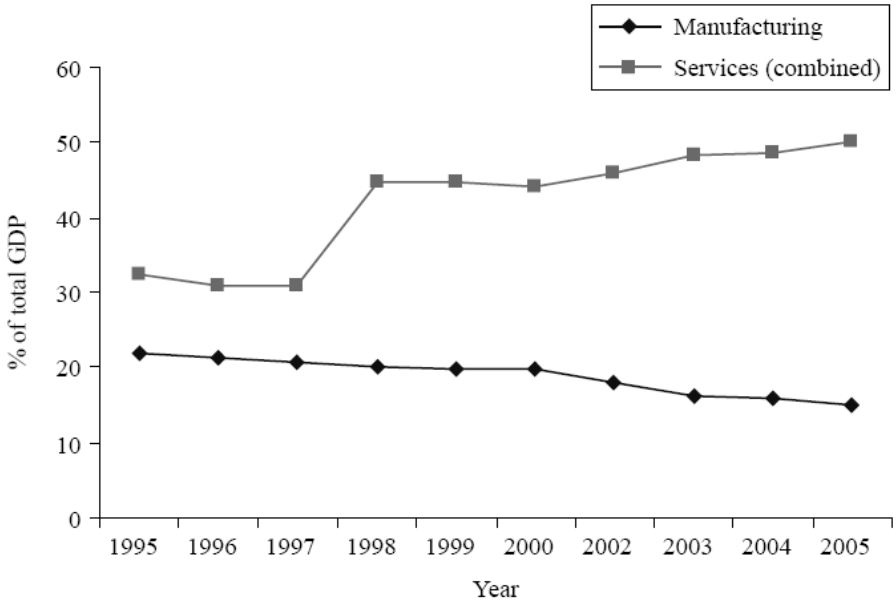


figure 1.1: the relative shares of GDP represented by the manufacturing and service sectors in the UK (taken from Oke, 2007)

In many companies which would traditionally have been regarded as manufacturing firms, service activities now account for a greater share of income than their manufacturing operations. The list includes Hewlett Packard (Brown, 2000), General Electric (Mathieu, 2001), International Business Machines, Siemens (Davis and Heineke, 2005) Shell, British Petroleum and Rolls-Royce (Neely, 2007). These statistics often make confusing reading, since many of the companies in the supposed service industries manufacture products or at least design products to be manufactured. They have led many to embrace the "mis-guided notion" that manufacturing should be left to other nations, while developed nations focus on services (Rose, 2008).

Blurring lines

A distinction has traditionally been made between manufacturing and service industries based on their outputs. Service industries are seen as offering something which is intangible, is not tied to a physical product and which does not result in ownership (Kotler, 2003). Manufacturing industries on the other hand produce tangible products, normally intended to be owned by the customers who purchase them. Theodore Levitt famously declared the distinction between industries to be redundant and claimed that "everyone is in services" (Levitt, 1972). Levitt also argued that as products become more complex, more services are required to support and sell them. For example, as modern automobiles are more reliant on electronics, maintaining them requires specialised knowledge and professional servicing. Products are

normally accompanied by some facilitating services while services are often facilitated by products (Fitzsimmons and Fitzsimmons, 2006). A purchase therefore consists of both products and services.

It is increasingly recognised that the lines between products and services, and the companies that produce them are blurred or blurring (Wise and Baumgartner, 1999, Correa et al., 2007, Ward and Graves, 2007). This means that products and services are combined in packages which some refer to as Product-Service Systems (PSS). These are defined as "a marketable set of products and services capable of jointly fulfilling a user's needs" (White et al., 1999, Mont, 2002). In this research the term PSS will be used, but the literature in this area is characterised by a divergence in terminology. For example, terms such as "service offering" (Grönroos, 2000), "bundles of benefits" (Davis and Heineke, 2005) and "value packages" (Correa et al., 2007) are used to describe apparently identical concepts. The transition to service orientation was first referred to as servitization, but one report used the term servicization (White et al., 1999), an anomaly which is indicative of the lack of communication and integration between different disciplines and research groups.

The term 'servitization' was first used by Vandermerwe and Rada (1988) to describe a transition from manufacturing of products towards "bundles of customer focused combinations, dominated by service". In their study of senior managers in both manufacturing and service firms, they found managers more likely to view customer needs as a whole than retain the "old and outdated focus on goods or services". They stated that "the primary objective of business is to create wealth by creating value" and more of this value is added by services than in the past. It is now claimed that we are moving into an "age of access" (Rifkin, 2000), in which ownership of products is less desirable, but rather access to the value of their output is sold.

Ownership to access

The literature focuses on the transition from goods dominance to service dominance (Vargo and Lusch, 2004a) or the servitization (Vandermerwe and Rada, 1988) of manufacture. It has been argued (CE-NET 2004) that firms will increasingly collaborate in virtual enterprises to meet customers' demand for "sustainable access" to the benefits of products. These firms face challenges in capturing customer needs, combining their resources and managing their integration to deliver these benefits. As Rifkin (2000) argued, the move from selling goods to providing service, is part of a wider transition from 'ownership' to 'access'. One of the outcomes of this transition is that retaining physical property and charging customers for its use is considered by some to be a more viable business model than simply

transferring ownership (Correa et al., 2007, Karlsson, 2007). Rather than receiving a one-off payment for goods, many companies find it preferable to have a continuous stream of revenue from service provision.

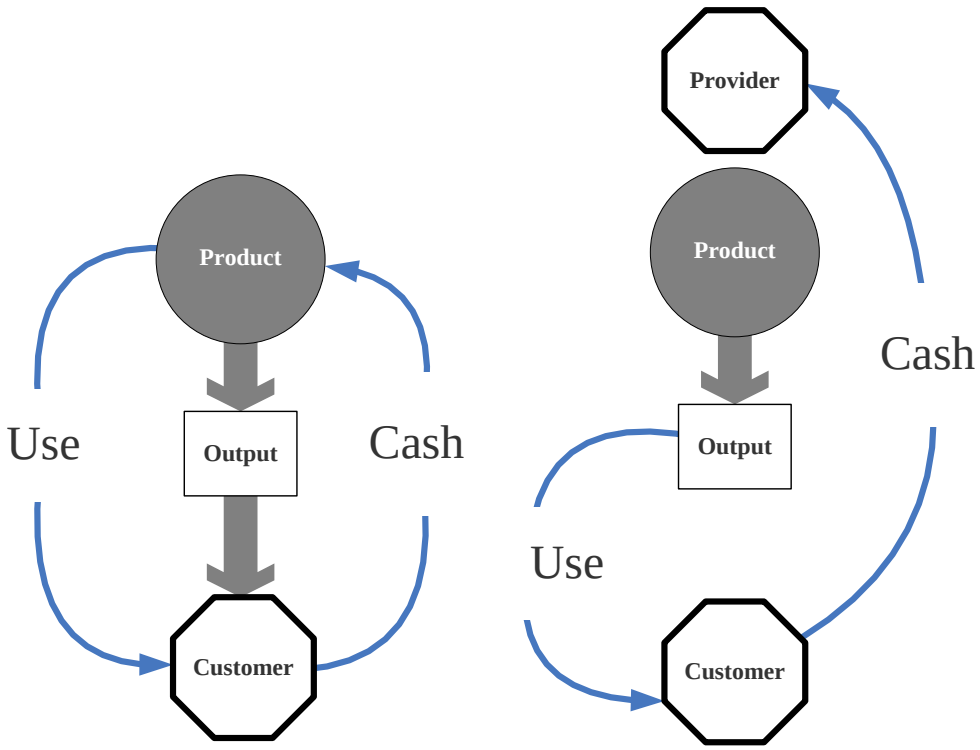


figure 1.2: A new business model involves paying for the value (in use) of products (adapted from Prahalad and Ramaswamy, 2004, and Baines et al., 2007)

The transition can be seen in figure 1.2, which demonstrates the difference in the way products are sold. In the traditional model, on the left, ownership of the product is purchased by a customer, who extracts value from it and is responsible for its maintenance and disposal. In the second model, the customer pays for the value which is extracted from a product, while the producer retains ownership and responsibility. The 'output' of the product may be the power produced by an aircraft engine. It may also be a document produced by a printer, in which case the customer is charged by the page for the service of printing, rather than the up-front cost of the printer. This requires the producer to maintain the product, which in turn means monitoring performance to ensure it remains functional at all times.

1.2 Reasons for a transition

The early literature on PSS focused on the potential of product-service offerings to reduce the environmental impact of products (Tukker and Tischner, 2006b, Baines et al., 2007). More recently, the servitization literature has focused on the financial benefits of offering services (Benedettini and Neely,

2010). In figure 1.3, a number of different benefits, described throughout the literature are collected. This demonstrates some of the reasons why a product-service transition might be an attractive proposition.

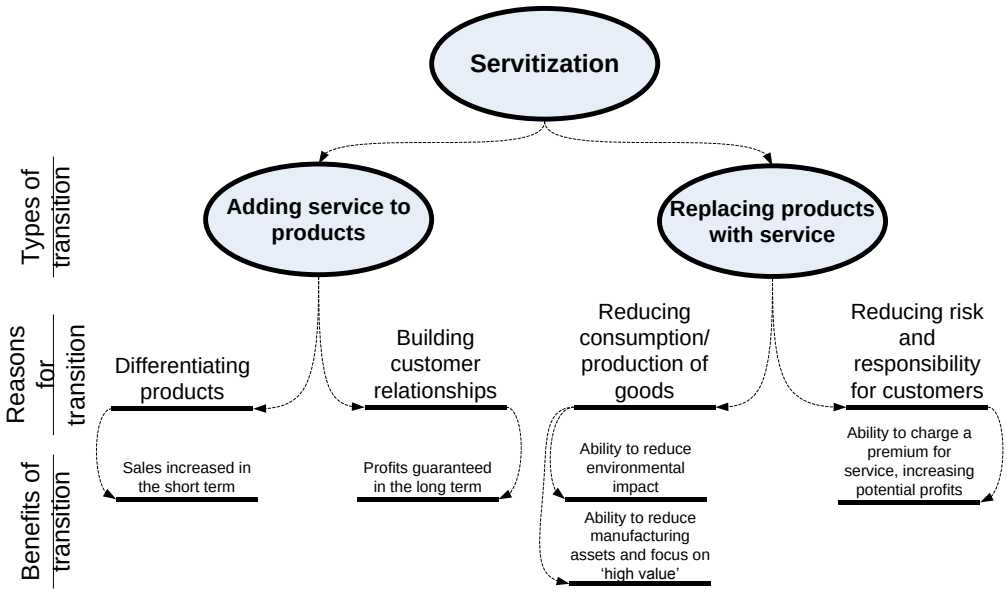


figure 1.3 – reasons for a product-service transition

Reasons for a transition

- *Differentiating products:* with many markets now saturated, adding services is thought to enable companies to offer an inimitable value proposition.

- *Building relationships:* whereas transactional product sales often mean that customers are distant and difficult to understand, services offer an opportunity to lock customers into a relationship, enabling knowledge sharing and long term profits.

- *Reducing consumption:* if selling access to products means fewer products need to be produced, then arguably the environmental impact of industry can be reduced.

- *Reducing risk:* when selling access, the seller should normally take responsibility for the availability of the product, so that customers can focus on their core processes and treat access as a fixed, known cost.

Catching up

Vandermerwe and Rada (1988) highlighted the growing importance of services in corporate strategy and the associated potential for profit which motivated change. Until recently, this concept, which emerged

from the business world, was not a major concern for academics. This can be taken as an indication that businesses is ahead of academia in this area. Current research in the area of servitization is led by industry, in collaboration with academics. Organisations such as IBM (IfM and IBM, 2008) have taken an active role in setting the research agenda, mainly identifying the requirement for interaction between different disciplines and between industry and academia. This research will seek to avoid being restricted by disciplinary 'silos' and examine a variety of perspectives, which is needed to understand the complexity of the product-service or ownership-access transition.

What is apparent, from comparison of literature with examples in the business world, is that academic research is catching up with the phenomenon which has been observed in practice for a number of years. This is evident in studies which question the accepted wisdom of the benefits of servitization (Fang et al., 2008, Neely, 2008) and efforts to understand the concept in light of existing theory (Alvizos and Angelis, 2010). The transition to service is clear in many industries and businesses, but the implications have not been fully understood. To this end, qualitative case study research continues to be the most common approach in this area. While these studies have investigated various aspects of servitization and PSS, one area which is relatively under-researched is the important role of design within this context.

1.3 The role of design in product-service

Davies (2003) presented Alstom, the train manufacturer as an example of a company moving "downstream into service provision" (Wise and Baumgartner, 1999) by providing "solutions" (Brown, 2000). He cites their contract with the London Underground's Northern Line, which specifies that 96 trains should be operational per day, for 20 years. The customer's demand is not specific, in technical terms, as would be expected, but focuses on the utility. For the customer this means offloading responsibility for the product and indeed the requirement for ownership. For Alstom this contract represents a stable source of income over a long time period. Alstom, is mentioned along with other companies such as Ericsson and Thales, all of whom decided to sell manufacturing assets in order to focus on value adding services. While Alstom "outsources 90% of the components in trains" however, it "continues to design critical components…in-house". The same can be said of Ericsson which designs and manufactures complex components and outsources the manufacture of others.

Both of these examples show companies capitalising on the business opportunities offered by services. In order to profit from these opportunities, the companies have introduced some changes in the way they

work. In the literature, aspects such as the business models are addressed. One major topic, however, which is vital to the success of these companies, has thus far not been adequately researched. In order to deliver its service, Alstom produced an adequate number of trains and ensured its supporting infrastructure could maintain them in operation. The operating requirements of the train, however, would most likely be altered to reduce the cost of their maintenance. This entails a change in the design of the product, to maximise its utilisation, lengthen the time between services and reduce the number of failures. In the second example, the focus of the company has switched to the knowledge intensive part of their business – the design of technology. This again shows that there are design implications associated with their transition. As these companies increase their outsourcing, they are also more likely to require supply chain design, which adds another set of implications.

It is evident from the descriptions of companies such as these that design plays an important role, but is used differently in each company. The decision to adopt a service approach affects the design of products and the design of the organisation. In the case of one Scandinavian manufacturer of printing presses, redesigning products allowed a service to be sold to customers who had been reluctant to purchase the product alone. The company identified its customers' main concerns and recognised that moving to service provision, while making profits more stable, would require design changes. This can be seen as an example of how design is used to link customer needs with the organisation's capabilities to create sustainable value. The following example will describe the experience of this company, using information from personal communication with a researcher who conducted a detailed case study of this company (Nixon, 2008). This is used for illustrative purposes, to demonstrate the link between design and servitization and to suggest the value of studying this topic further.

Example – offering printing presses as a service

This company is one of the world's largest manufacturers of printing presses, as well as large paper making machines. It designs, manufactures and assembles high value machines, costing up to €30 million, such as the one shown in figure 1.4. These were previously sold on a one-off transactional basis, but sales began to fall, prompting action from the company. Increasing competition and decreasing profit margins forced them to identify and address customers' issues, initially thought to be the high purchase cost. Two issues were identified:

- High cost and complexity of maintenance

The cost incurred through machine down time meant most users employed full-time maintenance staff, often for 16 or 24 hours a day, at their own cost. They also carried the cost of spare components, kept in case of breakdown.

- Fear of obsolescence

The investment made in purchasing these machines is high so it is expected that they work for the duration of the 10-15 year life expectancy. During this lifetime, however, competitors purchasing newer machines have a significant competitive advantage.

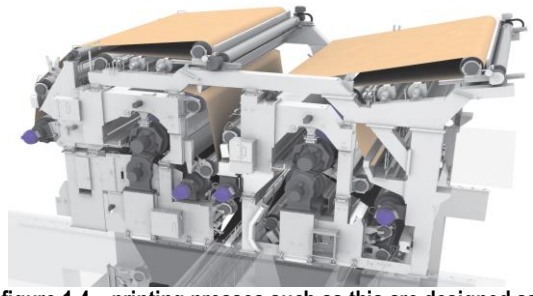


figure 1.4 – printing presses such as this are designed as part of product-service offerings (image taken from manufacturer's website)

Improvements in operational efficiency and productivity, which could make current models obsolete, concern potential customers. The first issue can be overcome by offering to take on responsibility for maintenance, through service contracts. The second could be solved if the service contract gives customers access to the latest machines, and the company replaces obsolete ones. With such high value equipment, however, this would be potentially un-profitable. In order to profitably move into service provision, their solution required redesign of their products.

A detailed Failure Mode and Effect Analysis (FMEA) allowed the re-design of components most likely to fail, making more durable or easier to replace without interruption. With a service contract creating an incentive to prevent the machine failing, electronic monitoring was incorporated into the design to warn of potential failure. To solve the second issue, technologies were "ring-fenced" within modules which could be easily replaced. Ongoing analysis of technological trajectories is now a part of the company's activity and re-assures existing and potential customers who fear obsolescence.

In this company, understanding customers was vital and identifying their value expectations allowed lucrative service provision to counteract falling revenue from sales. When value expectations were defined, creating this value required design. The solutions provided make use of the capabilities already available, for example the manufacturing facilities required to produce such products and the knowledge of employees which allows an efficient maintenance service to be provided.

1.4 The role of design in organisations

In the product-service context, research has focused on the design of products to enable re-manufacturing (Sundin, 2009) or on developing a methodology for designers (Morelli, 2003). Studies of product-service design and development, within traditionally manufacturing organisations are scarce. While the examples above show companies utilising or modifying their design resources to deliver product-service offerings, these issues can be seen as a gap in the body of knowledge. One possible reason for this is the lack of a theoretical framework to enable design to be investigated in organisations. Numerous studies over many years have studied the role of design, but recent interest has been particularly high (Luchs and Swan, 2010). Perks et al (2005) investigated the role of designers, concluding that this role had evolved over time, from being relatively peripheral to being central to new product development (NPD). In another recent study, (Micheli et al., forthcoming) designers' perceptions of their role in NPD are compared to the perceptions of their managers. Schneider (1989) is among those who have argued that designers' role in organisations goes beyond NPD, since their training gives them a unique mix of conceptual and pragmatic skills. Martin (2009) referred to design thinking as a powerful approach to management, which others (Nussbaum, 2004, Brown, 2008) have also promoted. They presented design as a powerful strategic tool (Kotler and Rath, 1984) which is underused. Indeed, while several have spoken of the strategic skills of designers, many companies did not see the value of these skills

> *"the nearest their designers ever get to the board is likely to be the one that they draw at."*
> (Schneider, 1989)

In short, design affects many aspects of organisations, but research and industry view design primarily as related to products. Definitions of design normally explicitly identify it with the development of products

> *"designing is the planning process for artefacts."*
> (Gorb, 1990)

Or treat service design as an afterthought

> *"design is the conscious decision making process by which information (an idea) is transformed into an outcome, be it tangible (product) or intangible (service)."*
> (von-Stamm, 2006)

This is partly because design is most visible where it is a function within NPD, carried out by trained designers. For example, a study by the Danish Design Centre (2003) defined design in its capacity within NPD and designers as those employees holding a design qualification. Meanwhile, Hollins and Hollins

(1991) argued that design education, particularly in Business Schools, had not kept up with the wide range of activities and service industries that students are likely to find careers in.

Designers' skills allow them to contribute to activities they were not necessarily trained for. Yet non-designers also carry out design activities, making it even more confusing to study design in organisations. The phenomenon of silent design (Gorb and Dumas, 1987), whereby non-designers contribute to design, has troubled researchers for many years and still represents a challenge (Candi, 2009). Studying design in organisations, therefore, requires a theoretical framework which overcomes such challenges. And studying design in product-service organisations requires this framework to be focused not only on product design, but on other activities which should be treated as design.

1.5 Aim of the research

The aim of this research is

"to better understand the role of design in organisations which provide product-service offerings – or those which seek to offer access to, rather than ownership of, their products."

It examines a number of research questions, through in-depth investigation of businesses to illuminate how the reality of product-service business relates to concepts in the literature. The research combines deductive and inductive approaches, using case studies for both theory testing and theory generation. The intended outcome is to connect management theory to management practice, presenting practical implications and recommendations for businesses.

This statement contains (at least) two terms which require clarification. The research will explore these two terms, to develop an understanding based on previous literature and original case study research. Briefly, 'the role of design' refers to the design activities conducted in a company, both by designers and individuals whose job title does not contain the word design. In this research, investigating the role of design involved identifying and classifying these design activities and examining the scope and influence of design in organisations. Secondly, 'product-service offerings' refer to a service agreement, which relies on the development, production and delivery of a product by the service provider. This typically means that what is offered is access to, but not ownership of, a product. Chapter 4 will present a study which sought to investigate the role of design in companies and proposes an approach to classifying and comparing design in different companies. Chapter 5 investigates product-service organisations, proposing a framework which describes the challenges and considerations for these organisations, when

designing their offerings. Chapter 6 returns to the original question through an in-depth study of design in a product-service organisation.

1.6 Objectives

Traditionally, a separation has been made between products and services as economic entities. Products are the result of 'secondary' economic activities such as manufacturing while services are 'tertiary' or other activities. Recent literature describes the increasing importance of services in manufacturing companies and the convergence between products and services, both of which are seen as means to the end goal of profitably satisfying customer needs. The literature identifies a transition which is referred to as the 'servitization' of manufacturing companies. The offerings of these companies are referred to by various names including product-service, integrated solutions and value packages. All of these are combinations of product and service, two elements which have traditionally been treated separately. This research investigates businesses which are making or have made a transition to the provision of service. Its particular focus is on the role or position of design and how this is affected by a transition from designing and selling products to delivering services which rely on manufactured products. The research examines the role of design in the context of 'servitized' companies, and so there are three key objectives:

- To develop an understanding of design, and propose a method of measuring it which allows the comparison of companies in different sectors.
- To develop an understanding of product-service offerings and identify the challenges faced by organisations in designing them.
- To develop an understanding of design in a product-service organisation and the interplay between p-s and the role of design. This includes the implications on the offerings made to customers, the processes used to develop the offerings,

The objectives divide the overall topic of investigation into sections contributing to the overall understanding. The first objective deals with the topic of design, focusing on how the nature of design activities in businesses from different sectors, producing different products and services, can be compared. This objective was addressed by a literature review addressing the question "what is design?" and case studies which are discussed later in this report. The second objective concerns the product-service offerings mentioned in the aim, and the organisations which design and deliver them. The

research questions related to this objective guided a literature review seeking to understand existing knowledge of product-service offerings and identify design implications through case examples. The final objective focuses on the overall question of the role of design in product-service organisations. A case study of a large, product-service organisation sought to answer research questions related to the design process in this organisation and identified characteristics of this process, such as the increased involvement of non-designers in design and the processes designed to facilitate their interaction.

Each of these objectives is addressed by one chapter describing the relevant literature and results of an empirical investigation to contribute to the knowledge in the area. Each of these chapters are intended to be seen as self-contained studies in their own right. The list of relevant publications at the beginning of each of chapter 4, 5 and 6 demonstrates where these studies, or parts of them, have been peer reviewed or presented at academic conferences. It has been noted that research questions such as the one seeking a definition of design are rather broad. It should be noted, therefore, that these research questions represent the questions guiding both the literature reviews and empirical investigations.

1.7 Research questions

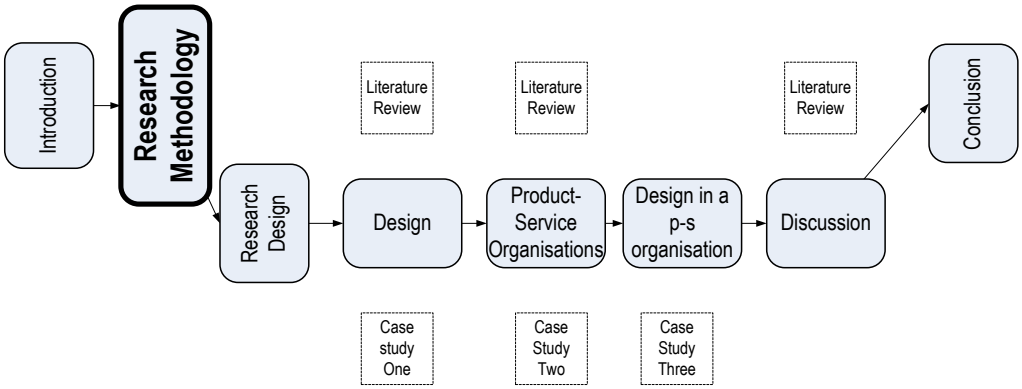
The following research questions, under three topic headings, were identified as relevant issues which are not adequately addressed in existing literature. The ultimate goal of the research is to provide answers to these questions, thereby offering a contribution to knowledge.

1) The role of design in business
   (Chapter 4, based on a study of design spending in firms)
   - How can design activities be classified in companies?
   - How can the design activities in be measured in a manner which allows comparison between organisations and between sectors?
2) Product-service organisations
   (Chapter 5, based on a study of product-service organisations)
   - Why do companies make a product-service transition and what is the outcome of this transition?
   - What are the implications and challenges of designing a product-service offering?
3) The role of design in a product-service organisation
   (Chapter 6, based on a study of design effort in an aerospace company)
   - How does a product-service transition take place and what is its outcome?
   - How are the products at the heart of a product-service offering designed?
   - How is the organisation structured to develop product-service offerings?
   - How is design used in a product-service organisation?

Chapter 2
Research Methodology

> *"As we know, there are known knowns: there are things we know we know. We also know there are known unknown. That is to say, we know there are some things we do not know. But there are also unknown unknowns, the ones we don't know we don't know."*
>
> (US Secretary of Defense, Donald Rumsfeld, 2002)

This chapter is concerned with knowledge. Specifically, it is concerned with the means of creating the knowledge in this research project. It presents a review of relevant sections of the literature on research methodology, to explore possible research approaches and identify an appropriate one. Methods, tools and philosophical assumptions which are described in the social science methodology literature were explored in an attempt to understand how this research should be done. This chapter will shed some light on the result of this attempt.



This chapter sets out the approach followed in this research, by examining different aspects of research methodology and exploring the assumptions which influence the research and the ways of ensuring its quality. Following the sequential order used by Crotty (1998), the following sections begin with an exploration of epistemology and theoretical perspectives, presenting philosophical positions in research. This is followed by a description of research strategies, presenting different logical approaches and connecting these to the philosophical positions. Next the methodology used in the research is described and some discussion of specific methods is provided, leading into the more detailed descriptions of the research process in chapter 3. In any research project, it is important that the selections made in each of these categories are appropriate and relevant to the research questions under investigation. Each category is discussed in turn, allowing the appropriateness of the selections to be judged, in order to assess the ability of the research to create knowledge.

2.1 Creating knowledge

For the general public, knowledge can be accepted as valid due to any of three sources of evidence. These are authority, for example the words of an expert; intuition, which may be based on beliefs; and logic, which relates to the explanation of the rationale behind facts (Labovitz and Hagedorn, 1971). Only if there is insufficient knowledge to answer a particular question does it become necessary to look elsewhere. For researchers and the largely academic audience which judges their work, things are a lot less simple. Some management scholars feel that their field has “paid dearly for the obsession with rigor” (Mintzberg, 1979), arguing that research methods have been too restrictive. Despite this, it is inconceivable for academic research to be given the name without following some kind of process, which separates it from the inquiries of the general public. Research has been described as

> *"…a disciplined process for answering questions about some aspect of the observable, touchable world."*
>
> (Dixon et al., 1987)

Those who are unsatisfied with the answers arrived at will most likely question the way in which the research was conducted. Denscombe (2002) identified this as a challenge facing researchers seeking to conduct 'good research' in an environment where there is a lack of agreement among experts. What one considers good is likely to be criticised by another who has a different viewpoint. The results of research are almost never entirely conclusive and are likely to be disproved or countered by other subsequent studies. It is therefore the researcher's responsibility to minimise criticism by providing arguments for decisions made which seem logical regardless of the reader's position. To this end, researchers need to show a "critical design attitude" (Clough and Nutbrown, 2002) in their work, meaning they demonstrate a logical and reflexive relationship between research questions, field questions, literature review, data analysis and research report. On the other hand,

> *"…[researchers who] just apply approved methods without being aware of the subjective foundation of their activities are not scientists, they are technicians"*
>
> (Gummesson, 2000, p18)

At the beginning of any research, there are questions which the researcher should ask. These questions are listed by Cresswell (2003) and their relationship is shown in figure 2.1

- What epistemology informs the research?
- What theoretical perspective lies behind the methodology in question?
- What methodology governs our choice and use of methods?
- What methods do we propose to use?

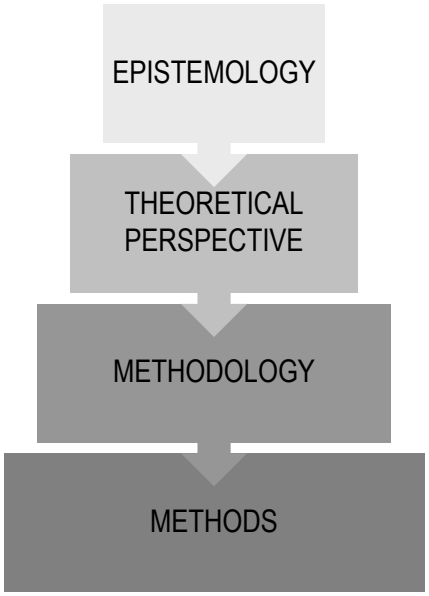


figure 2.1 – relationship between elements of research (Crotty, 1998)

While most doctoral students can be expected to have encountered various research methods and methodologies when they begin their studies, philosophical aspects of research are often unfamiliar and confusing. These philosophical issues represent a minefield for a research student, due to different texts offering differing and apparently conflicting views. These may be deliberate due to the writers' philosophical standpoints, or may be unintended use of terminology. For example, while Crotty (1998) classes positivism and hermeneutics as theoretical perspectives, Guba and Lincoln (1994) present the former as a paradigm and the latter as a

methodology. The use of terminology is confusing and the boundaries between concepts are not always clear so there is flexibility in which options to take, but "the goal is to avoid gross misfits – that is, when you are planning to use one type of strategy but another is really more advantageous" (Yin, 2003).

2.2 Epistemology and theoretical perspectives

"An epistemology is a way of understanding and explaining how we know what we know."
(Crotty, 1998)

Epistemology is concerned with the nature of knowledge, which is a topic some argue is essential for anyone aspiring to create new knowledge. Crotty lists Objectivism, Constructionism and Subjectivism as examples of epistemology. There are numerous other perspectives, but in most texts concerned with research methodology, these are presented in terms of two key positions, often confusingly given different names. As Miles and Huberman (1994) put it, "positivism or constructivism are probably the basic representatives of a list of alternative paradigms" which inform research. Denscombe (2002) similarly says that "despite the complex debates and sophisticated theorizing that have gone on for many years, the notions of positivism and interpretivism retain currency in terms of common parlance among researchers." The difference between the two is that one regards knowledge as something which exists and can be discovered, while the other sees knowledge as something that is 'socially constructed' and therefore does not exist independently of the people who create it. One aims to be objective and the other acknowledges its subjectivity. Table 2.1 presents typical descriptions of the differences.

	Positivism	**Social Constructionism**
The observer	Must be independent	Is part of what is being observed
Human interests	Should be irrelevant	Are the main drivers of science
Explanations	Must demonstrate causality	Aim to increase general understanding of the situation
Research progresses through	Hypotheses and deductions	Gathering rich data from which ideas are induced
Concepts	Need to be operationalised so that they can be measured	Should incorporate stakeholder perspectives
Units of analysis	Should be reduced to simplest terms	May include the complexity of 'whole' situations
Generalisation through	Statistical probability	Theoretical abstraction
Sampling requires	Large numbers selected randomly	Small numbers of cases chosen for specific reasons

table 2.1 – implications of philosophical positions (Easterby-Smith et al., 2002)

Positivist v interpretivist

Positivism is guided by the principle that only knowledge confirmed by the senses can be treated as knowledge (Bryman, 2001). Knowledge is generated by deducing hypotheses from existing theory and attempting to disprove them by experimentation and measurement. Positivism is seen as an application of the 'scientific method' used in natural sciences (Denscombe, 2002) and is often criticised by researchers in the social sciences who feel it is less applicable outside of the laboratory. The other position which researchers most commonly take in social sciences assumes that knowledge is 'socially constructed' or embedded in the interactions between people and their environments. The researcher uses qualitative methods such as interviews or ethnography to extract information from the subject or subjects of their investigations, rather than testing theoretical hypotheses. They should, however, enter the field with "an open mind not an empty head" (Cresswell, 1994).

Tables such as the one above can be found in numerous texts related to research methodology in social sciences, but some question whether these descriptions are really meaningful (e.g.Weber, 2004). Instead, Weber suggests they may be the result of misunderstanding or frustration on the part of researchers taking a less positivist perspective, who have suffered unfavourable reviews of their research. Weber (2004) refutes some of the claims of 'interpretivists' who he finds simply fail to understand positivism.

> *"I gave the example of the 'reality' that would occur if one were to step off the ledge outside the window of my office (given that my office is on the third floor of my building). I've yet to find a colleague who calls herself/himself an interpretivist willing to undertake the experiment to show me that the outcome I'm confident would occur is a perception rather than a reality!"*
>
> (Weber, 2004, pg 5)

Weber argues that even if the proposed differences in beliefs were true, both positivists and 'interpretivists' try to gain more knowledge about the world. The difference, in his view, is merely that 'positivists' seek to remove any bias or subjectivity while interpretivists seek to make their assumptions and biases explicit but do not believe they can ever be completely removed. Both approaches have value in certain circumstances, but for researchers, the key is to ensure the philosophical position does not conflict with the methodology used to conduct their research. In reality, most research falls between the two extreme positions described, for example Guba and Lincoln's continuum, shown in table 2.2. Similarly the continuum in table 2.3, based on the work of Järvensivu and Törnroos (2010) gives an insight into different philosophical positions. The latter adopt an intermediary position of moderate constructionism, which recognises that, while there may be an absolute truth, there are also different

viewpoints and the researcher should seek to create usable knowledge through analysis of these multiple viewpoints. They argued that this approach differs from naïve realism which seeks consensus to identify the true reality and naïve constructionism which treats all viewpoints as equally valid.

Item	Positivism	Postpositivism	Critical theory et al	Constructivism
Ontology	Naïve realism – "real" reality but apprehendable	Critical realism – "real" reality but only imperfectly and probabilistically apprehendable	Historical realism – virtual reality shaped by social, political, cultural, economic, ethnic and gender values, crystallized over time	Relativism – local and specific constructed realities
Epistemology	Dualist/objectivist; findings true	Modified dualist / objectivist, critical tradition / community, findings probably true	Transactional / subjectivist, value – mediated findings	Transactional / subjectivist, created findings
Methodology	Experimental / manipulative, verification of hypotheses, chiefly quantitative methods	Modified experimental / manipulative, critical multiplism, falsification of hypotheses, may include qualitative methods	Dialogic / dialectical	Hermeneutical / dialectical

table 2.2 – a continuum of philosophical paradigms (Guba and Lincoln, 1994)

	Naïve realism	Critical realism	Moderate constructionism	Naïve constructionism
Ontology	Only one, true reality exists; universal truth claims apply	There is a reality; specific local, contingent truth claims apply	There may be a reality; specific local, contingent truth claims apply	There is no reality beyond subjects
Epistemology	It is possible to know exactly what this reality is through objective, empirical observations	It is possible to move closer to local truths through empirical observation, bounded by community-based critique / consensus	It is possible to understand local truths through community-based knowledge creation and empirical observations bounded by subjectivity	It is possible to form an understanding of the subjective reality through analysis of the subject's account of knowledge
Methodology	Direct empirical observation	Empirical observation, bounded by subjectivity and community-based critique / consensus	Community-based knowledge creation through empirical observations bounded by subjectivity	Analysis of knowledge structures and processes by observing texts
Research process	Deductive; theory testing	Abductive; theory generating and testing	Abductive; theory generating and testing	Inductive; theory generating

table 2.3 – a continuum from naïve realism to naïve constructionism (Järvensivu and Törnroos, 2010)

Selecting a position

If the topic of research was to identify what a particular philosophical position means, the approach to research would differ according to the epistemology in use. In a positivist study, the researcher would most likely seek consensus and view the differing descriptions given by different sources as a form of measurement error in their quest for the true answer. Meanwhile a constructivist/interpretivist might insist

that there is no true meaning for the object of study and instead, each account is of value in itself since it represents reality as constructed by a person or group of people. They would also insist that generalising beyond a description given by a single source should not be attempted. Meanwhile, intermediate positions might consider that a true definition exists, but that differing descriptions are not necessarily false. Rather, the different accounts are someone's perception of the reality under investigation and allow an understanding of the truth from the perspective of that person.

In this instance, 'positivism' is most likely a social construct, since it arguably does not exist outside of the debates of the people who use the term. On the other hand, management issues – such as the use of design in businesses or the transition of manufacturers to service provision – can be seen as having different meanings when seen from different perspectives. Rather than seeking consensus in this study, the research examines questions from different perspectives, to build up a rich picture. This is done by questioning different companies (chapter 4 and chapter 5) or by exploring the questions from the perspectives of individuals within one company. Design, and service management, as should become apparent in the following chapters, are processes which require the involvement of different specialisms. It has been argued that studying them also demands the collaboration of researchers from different areas, typically marketing and operations, to see the full picture (e.g. Kwortnik and Thompson, 2009). Fisk (2008) used the example of blind men encountering an elephant, illustrated in figure 2.2, as a metaphor for the study of services, however, this can also be used to summarise the philosophical position taken within this research. As each of the men relies only on their sense of touch and is unable to see the whole, each one 'sees' an elephant differently. One may claim an elephant to be like a snake, another insisting that an elephant is like a tree, depending on which part of the creature they are closest to. In reality, they are all accurate, but limited.

Similarly, this research adopts the position that there may be a universal truth for the objects of the study, but that the perspectives of individuals are valuable in allowing this truth to be investigated from different angles. Depending on the source, this position may be described as post-positivist or critical realist, or closer to what Cresswell (2003) refers to as Pragmatist. A similar example was used by Peirce (1998) in describing Pragmatism. In drawing a series of lines, he demonstrated that these could be seen as curves or, if we view the whole, can be perceived as a representation of a stone wall. The drawing exists and cannot be said to be socially constructed, yet, the meaning attached to it is dependent on observations and the perspective of the observer.

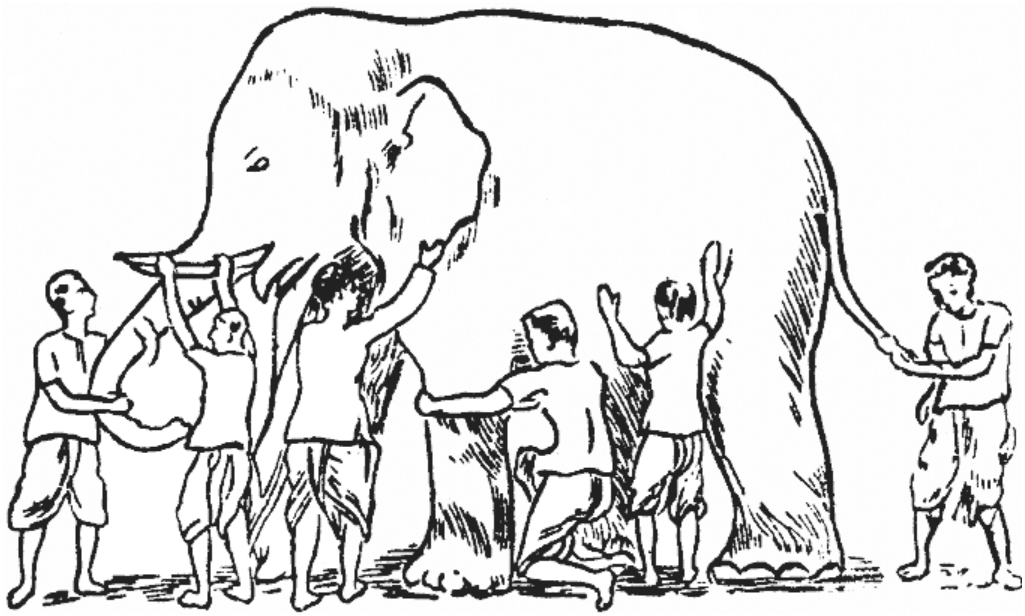


figure 2.2 – blind men 'researching' an elephant (Fisk, 2008)

2.3 Research strategy

As discussed, social research can involve a number of different philosophical positions. One of the implications of the chosen position is that it also influences the type of reasoning used. With the two extreme positions discussed, come two different types of reasoning – inductive and deductive. Martin (2009) argued that most people, unless they have studied philosophy or the history of science, are not exposed to formal logic and therefore are likely to have encountered only two types of logical reasoning. He describes these as follows:

> *"Deductive logic – the logic of what must be – reasons from the general to the specific. If the general rule is that all crows are black and I see a brown bird, I can declare deductively that this bird is not a crow.*
>
> *Inductive logic – the logic of what is operative – reasons from the specific to the general. If I study sales per square foot across a thousand stores and find a pattern that suggests stores in small towns generate significantly higher sales per square foot than stores in cities, I can inductively declare that small towns are my more valuable market."*
>
> (Martin, 2009)

Jarvensivu and Tornroos argued for pluralism, making use of a third type of reasoning – abductive – which involves alternating between inductive and deductive at different stages in the research process. Abductive reasoning was developed by an American Pragmatist, Charles Sanders Peirce, on the basis that neither inductive nor deductive reasoning could be used to prove new ideas with past data (Martin, 2009). Instead, he argued that logical leaps of the imagination arose when someone encountered data which did not fit the existing models and therefore proposed an explanation which does not seek to declare something true or false but posits what might possibly be true.

In less abstract terms, Jarvensivu and Tornroos (2010) presented abductive reasoning as a combination of inductive and deductive, used at different stages of a research project. As shown in figure 2.3, they saw that an abductive research project would involve the researcher moving repeatedly between theory and empirical data, with inductive and deductive reasoning being more appropriate in different phases of research. While some researchers are overly focused on either theory or data at the expense of the other, this type of 'pluralism' offers the opportunity to use both, ensuring both a contribution to theory and a close grounding in the data.

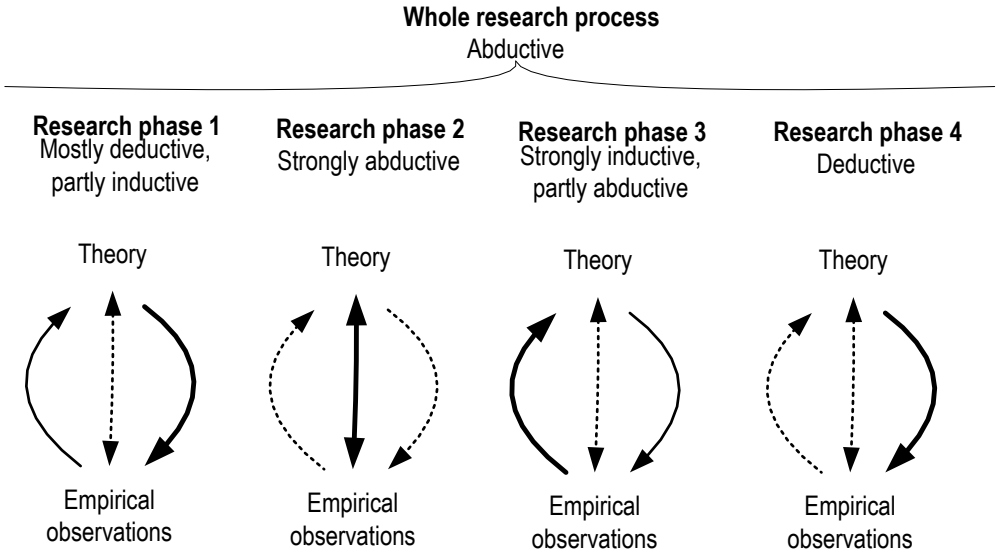


figure 2.3 – An example of an abductive research project, utilising inductive and deductive reasoning at various stage (Jarvensivu and Tornroos, 2010)

Blaikie (2000) distinguished between four different research strategies, adding retroductive to the three described above. He acknowledged, however, that Peirce used the terms abductive and retroductive almost interchangeably. Equally, Blaikie admits to approaching research from an interpretivist perspective, albeit a "middle-of-the-road" one, which influences his descriptions of these strategies, as shown in table 2.4.

Dubois and Gadde (2002) describe their abductive approach as systematic combining, a process where theoretical framework, empirical fieldwork and case analysis evolve simultaneously, which they argue is particularly beneficial for theory development. While they found other authors treated research as a linear and sequential process, they advocated a more iterative approach using abductive case studies. They argued that theory cannot be understood without empirical observations and vice versa. This leads to the belief that researchers should move back and forth between research activities, so that their theoretical

framework evolves as the study proceeds, directing the search for empirical data. Equally, new data can stimulate a change in the theoretical model, resulting in a search for more literature.

	Inductive	Deductive	Retroductive	Abductive
Aim	To establish universal generalizations to be used as pattern explanations	To test theories to eliminate false ones and corroborate the survivor	To discover underlying mechanisms to explain observed regularities	To describe and understand social life in terms of social actors' motives and accounts
From	Accumulate observations or data	Borrow or construct a theory and express it as an argument	Document and model a regularity	Discover everyday lay concepts, meanings and motives
	Produce generalizations	Deduce hypotheses	Construct a hypothetical model of a mechanism	Produce a technical account from lay accounts
To	Use these 'laws' as patterns to explain further observations	Test the hypotheses by matching them with data	Find the real mechanism by observation and/or experiment	Develop a theory and test it iteratively

table 2.4 – descriptions of four research strategies (Blaikie, 2000)

Selecting a strategy

Arguably, most research is iterative and messy, even when presented as a planned and structured process (e.g. Cham, 2008). Rather than moving in a clear, linear sequence as in figure 2.4, this research followed a complex iterative approach, involving a number of phases of research which were used to break the research question down into smaller topics and explore each in sequence, before presenting findings. This also involved moving back and forth between data and theory throughout the research.

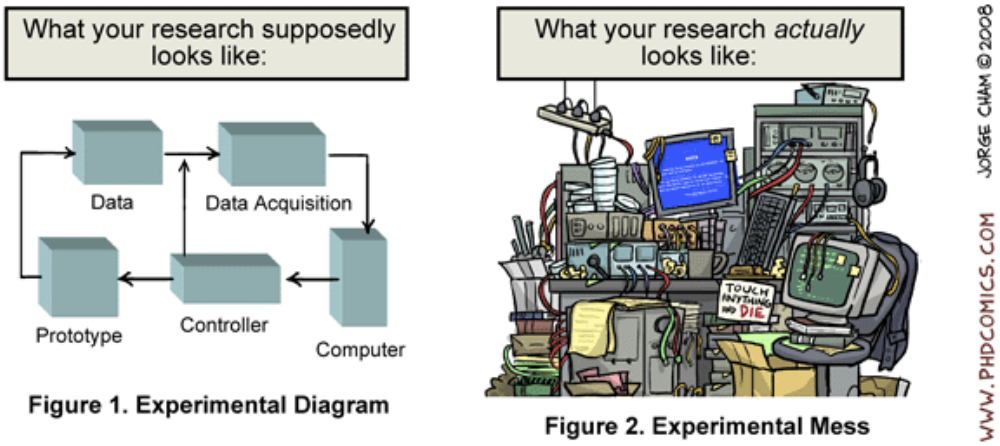


figure 2.4 – research is rarely as structured as it appears in research reports (Cham, 2008)

A purely inductive or deductive strategy would seek to adopt a single route to developing theory, either by generating empirical observations and comparing them to theory or by using existing theories to generate and test hypotheses in empirical contexts. An abductive approach, as outlined above embraces an iterative move between these strategies. In this research, a broad topic – the role of design in product-

service organisations – is first broken into two topics, each of which is explored through a review of literature and empirical work. The findings of the empirical work contribute to the development of a theoretical framework, as proposed by Dubois and Gadde (2002). This approach can be considered valuable because the research topics are not so new that only exploratory, inductive research is applicable – there have been numerous studies seeking to explore design and there is a growing body of literature on product-service. Neither have the topics been explored sufficiently that all the variables are known and a deductive, theory-testing approach would necessarily be successful – an anonymous reviewer of a proposed research project commented that a survey on the subject of product-service would limited value. An abductive strategy, therefore allows a combination of inductive and deductive approaches, to build theory and position it within the body of knowledge, thereby enabling this research to make a worthwhile contribution. Blaikie (2000) outlines the stages of research where different strategies are most suitable.

Objective	Research Strategy				Type of research question
	Inductive	Deductive	Retroductive	Abductive	
Exploration	***			***	What
Description	***			***	What
Explanation	*	***	***		Why
Prediction	**	***			What
Understanding				***	Why
Change		*	**	**	How
Evaluation	**	**	**	**	What and why
Assess impacts	**	**	**	**	What and why

table 2.4 – research strategies and their appropriateness at different stages of research (Blaikie, 2000) the number of stars is an indication of the appropriateness of the strategy

2.4 Methodology

In recent years, a noticeable shift can be seen in the content of research methodology texts, suggesting a move away from 'positivist' tendencies, toward a bewildering array of modern and post-modern philosophies. An ideal illustration of this change can be found through a brief examination of the contents list in the "Handbook of Qualitative Research" published by Sage. In its first edition (Denzin and Lincoln, 1994), the book contained chapters with titles such as "case studies" which demonstrate an emphasis on research methods. Later epistemology appears to have become more important and in the most recent edition (Denzin and Lincoln, 2005), ethics appear to be the major concern, with chapters addressing issues such as feminism and 'queer theory'. The chapter on grounded theory, for example, appears to have changed from an overview of the methodology (Strauss and Corbin, 1994) to a critique of positivist

and constructivist methods in grounded theory (Charmaz, 2000) to the advancement of social justice through grounded theory (Charmaz, 2005) in the handbook's three editions.

Research in Operations Management has traditionally favoured a positivist position but, as Meredith et al. (1989) argued, this focus was too narrow for its required purpose. They discussed the history of OM research, arguing that it had become too abstract and method oriented, focusing on the application of techniques as opposed to practical knowledge in real-life contexts. As OM is, by its nature, a practical field, Meredith et al. argued that researchers in the field should expand their work beyond quantitative modelling and essentially positivist approaches. While these methods are useful in addressing specific problems, in many cases, the subject of investigation cannot be adequately modelled, particularly when the involvement of people in the systems under investigation introduce subjectivity. They find some agreement from Johnston (1999), whose review of OM research argued that researchers needed to pay more attention to the contexts within which their research could be applied and to be of more use to practitioners. Johnston bemoaned the lack of consideration of customers, particularly in service OM research and the lack of emphasis on wider strategic issues. He was concerned that his colleagues had become too focused on solving specific problems which, although often arising from practical issues, paradoxically led to limited practical benefit from the research. Voss et al. (2003) proposed a solution by arguing that researchers could generate creative insights, produce new knowledge and be of more practical benefit to the end users of their research by using case studies in OM research.

Dubois and Gadde (2002) highlighted the fact that case study research "has not always been recognised as a proper scientific method". Many of the classic texts show an attempt to appease a positivist audience, who clearly did not appreciate the value of case studies. These texts often face criticism from modern day social science researchers, who feel less need to justify their qualitative methods as writers such as Yin (2003) or Eisenhardt (1989) to a positivist audience. Even qualitative approaches such as grounded theory (Glaser and Strauss, 1967, Strauss and Corbin, 1998) have been considered by some to be too positivist (Charmaz, 2000). This demonstrates that the methods and philosophical position are independent, though they interact. For example, Meredith et al. (1989, p309) present a framework for selecting research methods which are appropriate for different philosophies. The positions are defined on a matrix ranging from "natural" to "artificial" on one axis and "rational" to "existential" on the other. As shown in figure 2.5.

Natural ⟷ Artificial

Rational ↕ Existential

	Direct observation of object reality	People's perceptions of object reality	Artificial reconstruction of object reality
Axiomatic			• Reason/Logic/ Theorems • Normative Modeling • Descriptive Modeling
Logical Positivist / Empiricist	• Field Studies • Field Experiments	• Structured Interviewing • Survey Research	• Prototyping • Physical Modeling • Laboratory Experimentation • Simulation
Interpretive	• Action Research • Case Studies	• Historical Analysis • Delphi • Intensive Interviewing • Expert Panels • Futures / Scenarios	• Conceptual Modeling • Hermeneutics
Critical Theory		• Introspective Reflection	

figure 2.5 – a framework for selecting research methods according to philosophical position (Meredith et al., 1989)

Case study research

'Case study' is one of several terms in this research which are used both as a noun and an adjective. It refers to "both a process of inquiry about the case and the product of that inquiry" (Stake, 2000). It appears, however, that different writers take sides when they attempt a definition. Yin (2003) refers to case study as a specific research method and aims to establish the rules and techniques for implementing the method. He defines the case study as

> *"an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident."*
> (Yin, 2003, p13)

Eisenhardt (1989) concurs, defining the case study approach as "a research strategy which focuses on understanding the dynamics present within single settings" (p534). And, similarly, Meredith et al. (1989) classified case studies among research methods (figure 2.). Stake, on the other hand, emphasises the case, rather than the process of studying it as the defining aspect. He insists that

> *"Case study is not a methodological choice but a choice of what is to be studied"*
> (Stake, 2000, p435)

This is consistent with the view, shared by most writers, that researchers have a wide choice of methods and tools to apply when they choose to conduct case study research. It should be noted, before moving on to these methods, that Stake and Yin present two different perspectives on the subject of case study

research. While Stake describes himself and other qualitative researchers as social constructionists, Yin's perspective appears closer to positivism. On the other hand, Yin's approach is systematic and logical, providing researchers with guidance on case study research. For this reason, Yin is referred to throughout this chapter, despite reservations which some researchers express towards his recommendations.

Selecting a methodology

The previous section discussed the choice of methodology on philosophical grounds. A number of other factors are important in choosing a research methodology, including the audience.

> *"The paradigm of choice must be one that the audience understands or at least supports as a viable, legitimate methodology"*
>
> (Cresswell, 1994)

For Yin (2003), the choice depends upon, firstly the type of question which is posed, as well as the requirement for control of the events and whether contemporary or historical issues are addressed, as shown in table 2.5table 2.5. He states that case study research should be used when the research question is of the "how" or "why" form, there is no requirement to control behavioural events (unlike in an experiment) and the focus is on contemporary issues (unlike history or archival analysis). Eisenhardt (1989) similarly supports the view that case study research should be used where the researcher seeks to build theory by understanding events in their context.

Strategy	Form of research question	Requires control of behavioural events?	Focuses on contemporary events?
Experiment	how, why?	Yes	Yes
Survey	who, what, where, how many, how much?	No	Yes
Archival analysis	who, what, where, how many, how much?	No	Yes/No
History	how, why?	No	No
Case study	how, why?	No	Yes

table 2.5 – choice of research strategy (Yin, 2003)

The research questions require an in-depth understanding of how and why things happen – for example, how companies manage their design activities and why. The focus on contemporary events and the requirement to understand the context – how design activities are managed within the development of product-service offerings – in which processes occur, along with the philosophical assumptions, make case studies the most appropriate choice. Within the case study methodology, many methods can be used for generating and analysing data,

2.5 Methods

It is clear that the type of questions asked should be the starting point when selecting a methodology. Similarly, understanding the question is necessary for the selection of appropriate research methods to answer it. For Miles and Huberman (1994), the research questions follow logically from a conceptual framework which links the main things which should be studied. For other authors the research questions themselves are the starting point of the study. In general, research methods are classified as qualitative or quantitative.

Cresswell (1994) suggests the use of quantitative research where variables are known and theories may be tested, while qualitative research should be used where the research problem requires exploration and existing theory is inadequate. Stake (1995) argues that the principle difference is not the type of data, but between "inquiry for making explanations versus inquiry for promoting understanding". While one is concerned with causes, or why things happen, the other focuses on 'happenings' themselves.

> *"Quantitative researchers have pressed for explanation and control; qualitative researchers have pressed for understanding the complex interrelationships among all that exists"*
>
> (Stake, 1995, p37)

Similarly, Denzin and Lincoln (2005) add that qualitative researchers "seek answers to questions that stress *how* social experience is created and given meaning" (pg10) while quantitative studies emphasise measurement of causal relationships between variables rather than processes. The research questions stated previously concern subjects on which previous work is, to some extent, limited: there is a lack of theory available on which to build and the variables are not known well enough to enable quantitative measurement. This would suggest the use of a qualitative approach, which is best for 'inductive' research, exploring 'emerging' concepts about which there is insufficient previous research (Cresswell, 1994). A quantitative approach is best for 'deductive' work in which the phenomena studied are well defined and variables are known, allowing a hypothesis to be generated and tested. In later editions of his book, Cresswell (2003) acknowledged the use of "mixed methods", which are useful for validating results obtained from each method.

> *"Results from any one method are open to subjectivity and inaccuracy so it is necessary to triangulate the data using multiple but independent data sources."*
>
> (Driva, 1997)

Combining methods requires a researcher to follow a methodology which encourages triangulation as a means of studying something in greater detail. A case study is appropriate since it encourages the use of different methods in order to gain an understanding of contextual conditions (Eisenhardt, 1989).

Sources of evidence

What is true of case study research is that different methods may be used to conduct the study and collect the data which is used to write the case. Eisenhardt (1989) for example suggests data collection methods may include archives, interviews, questionnaires and observations and argues that either quantitative or qualitative data may be used. Indeed, the use of both quantitative and qualitative 'mixed methods' is considered to be good practice (Cresswell, 2003). In table 2.6 is a list of strengths and weaknesses of various sources of evidence.

Source of Evidence	*Strengths*	*Weaknesses*
Documentation	• Stable – can be reviewed repeatedly • Unobtrusive – not created as a result of the case study • Exact – contains exact names, references, and details of an event • Broad coverage – long span of time, many events, and many settings	• Retrievability – can be low • Biased selectivity, if collection is incomplete • Reporting bias – reflects (unknown) bias of author • Access – may be deliberately blocked
Archival Records	• [same as above for documentation] • precise and quantitative	• [same as above for documentation] • Accessibility due to privacy reasons
Interviews	• Targeted – focuses directly on case study topic • Insightful – provides perceived causal inferences	• Bias due to poorly constructed questions • Response bias • Inaccuracies due to poor recall • Reflexivity – interviewee gives what interviewer wants to hear
Direct Observations	• Reality – covers events in real time • Contextual – covers context of event	• Time-consuming • Selectivity – unless broad coverage • Reflexivity – event may proceed differently because it is being observed • Cost – hours needed by human observers
Participant Observation	• [same as above for direct observation] • Insightful into interpersonal behavior and motives	• [same as above for direct observation] • Bias due to investigator's manipulation of events
Physical Artifacts	• Insightful into cultural features • Insightful into technical operations	• Selectivity • Availability

table 2.6 – sources of evidence for case study research (Yin, 2003)

It is recommended to use different data sources for the purpose of 'triangulation', a term originally used by navigators to describe a method of calculating the location of their destination (Swann, 2006). In that context, triangulation is the process of using two known points to map the position of a third point, forming a triangle on a map. In a social research context, this equates to using multiple sources of evidence to reach conclusions, allowing a greater degree of confidence in the outcomes. This can be referred to as data triangulation, but Patton (1987) offers three additional types of triangulation:

- Of data sources (data triangulation)

- Among different evaluators (investigator triangulation)
- Of perspectives to the same data set (theory triangulation), and
- Of methods (methodological triangulation)

Unit of analysis

As Stake (2000) explained, not everything can be a case. While a doctor may be a case, 'doctoring' is not specific or bounded enough to be a case. The case is a specific example of something, which may or may not have implications that apply to other cases. Miles and Huberman (1994) describe a case as a phenomenon occurring within a bounded context. They refer to the unit of analysis as the "heart" of the study, surrounded by a "somewhat indeterminate boundary" which defines what will not be studied (p25). Identifying the unit of analysis is seen as the starting point for case study research. For example Miles and Huberman (p27) advise researchers to "start intuitively" by building outwards from the heart and identifying the boundaries by determining what *not* to study. The case itself may be an individual, a role, a group, an organisation or many other things. It may also comprise more than one of any of these, for example, in multiple-case studies. Yin (2003) classifies types of case study designs in the 2 x 2 matrix in figure 2.6, according to the number of cases and whether the unit of analysis is the case or is embedded within the case.

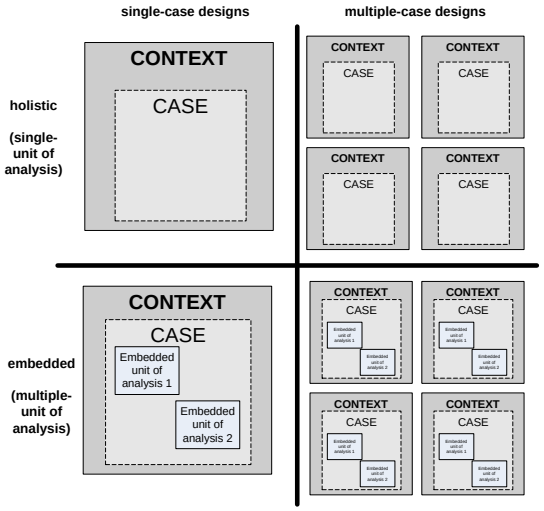


figure 2.6 – identifying the unit of analysis (Yin, 2003)

For example, the case may be an organisation, but the unit of analysis may be an individual giving an insight into the organisation. Additionally, one case may be the sole source of data or may be one of several which make up the study.

Generalising from cases

One of the most cited criticisms of case study as a research strategy is the limited capacity for generalisation. Most writers on the subject devote considerable space in their texts to justifying case study research in the face of this criticism. Yin's response to this criticism is to suggest that the critics should compare case study to experimental research as opposed to statistical analyses of large populations through representative samples. He argues that the subjects of an experiment do not

represent a sample and that the experiment's results are used for *analytic generalisation* – to expand and generalise theories – as opposed to *statistical generalisation* which is concerned with measuring frequencies (Yin, 2003, p10). Scientific research achieves generalisation by identifying a random sample, which represents a larger population. If statistical evidence of correlations between variables in the sample is obtained, then the findings can be generalised and considered to apply to the population as a whole. Glaser and Strauss (1967) were among the first to argue for the use of *theoretical sampling* in order to generalise findings to a theory. Their method of 'grounded theory' requires the identification of cases or informants by their ability to contribute data to develop a theory. This means of 'sampling' is unique in that it avoids 'representative' samples, instead focusing on what quantitative researchers refer to as outliers, which are considered more valuable in inductively creating the theory.

On the subject of sampling in case study research, Miles and Huberman (1994) state that within-case sampling is almost always *nested*, for example individuals studied are within a department, within an organisation. Additionally, they argue that the selection of informants or subjects of study is iterative and argue that theoretical sampling operates in progressive "waves" as the study progresses (p29).

Building theory

Eisenhardt (1989) focused on the subject of theory building from case studies. She presented a step-by-step process for building theory, which is shown in table 2.7. This process shows elements which are similar to Yin's approach, such as the concern with internal validity. Another notable aspect of the process is that the literature is not explicitly given attention until the very end of the research. While it is normal to expect that a literature review be conducted prior to empirical work, this approach reveals the influence of Glaser and Strauss' (1967) grounded theory methodology.

Step	*Activitiy*	*Reason*
Getting Started	Definition of research question	Focuses efforts
	Possibly a priori constructs	Provides better grounding of construct measures
Selecting Cases	Neither theory nor hypotheses	Retains theoretical flexibility
	Specified population	Constrains extraneous variation and sharpens external validity
	Theoretical, not random, sampling	Focuses efforts on theoretically useful cases – i.e. those that replicate or extend theory by filling conceptual categories
Crafting Instruments and Protocols	Multiple data collection methods	Strengthens grounding of theory by triangulation of evidence
	Qualitative and quantitative data combined	Synergistic view of evidence
	Multiple investigators	Fosters divergent perspectives and strengthens grounding
Entering the Field	Overlap data collection and analysis, including field notes	Speeds analysis and reveals helpful adjustments to data collection
	Flexible and opportunistic data collection methods	Allows investigators to take advantage of emergent themes and unique case features
Analyzing Data	Within-case analysis	Gains familiarity with data and preliminary theory generation
	Cross-case pattern search using divergent techniques	Forces investigators to look beyond initial impressions and see evidence thru multiple lenses
Shaping Hypotheses	Iterative tabulation of evidence for each construct	Sharpens construct definition, validity and measurability
	Replication, not sampling, logic across cases	Confirms, extends and sharpens theory
	Search evidence for "why" behind relationships	Builds internal validity
Enfolding Literature	Comparison with conflicting literature	Builds internal validity, raises theoretical level, and sharpens construct definitions
	Comparison with similar literature	Sharpens generalizability, improves construct definition, and raises theoretical level
Reaching Closure	Theoretical saturation when possible	Ends process when marginal improvement becomes small

table 2.7 – a methodology for theory building from case study research (Eisenhardt, 1989)

Interviewing

As described previously, many different methods of data collection are possible in case study research. For most qualitative researchers (e.g. Miles and Huberman, 1994, Strauss and Corbin, 1998), however, the study proceeds through the analysis of interview transcripts. For this reason, understanding how to conduct interviews is a vital part of case study research. Yin (2003, p74) describes levels of questions, showing how the interview questions are utilised in the case study.

1. Questions asked of specific interviewees
2. Questions asked of the individual case (these are the questions in the case study protocol to be answered by the investigator during a single case, even when the single case is part of a larger, multiple-case study)
3. Questions asked of the pattern of findings across multiple cases

4. Questions asked of an entire study – for example, calling on information beyond the case study evidence and including other literature or published data that may have been reviewed
5. Normative questions about policy recommendations and conclusions going beyond the narrow scope of the study

He advises that only levels 1 and 2 should be articulated in data collection and refers to these as the *verbal line of inquiry.* Meanwhile the others are research questions, or the researcher's *mental line of inquiry.*

Coding

Coding has been mentioned previously in this chapter, in relation to its use in qualitative methods and methodologies. It should be noted that coding in qualitative research is very different from quantitative work, where it normally refers to a number given to a category of information, for example male and female respondents to a survey could be given the codes 0 or 1. In qualitative research, coding is a way of reducing large amounts of information into more manageable and meaningful parts.

> *"Codes are tags or labels for assigning units of meaning to the descriptive or inferential information compiled during a study. Codes usually are attached to "chunks" of varying size – words, phrases, sentences, or whole paragraphs, connected or unconnected to a specific setting."*
>
> (Miles and Huberman, 1994, p56)

Coding involves indexing or categorising text by the themes addressed. It allows at least two forms of analysis (Gibbs, 2007):

- Text coded with the same label can be retrieved together to combine passages that are examples of the same phenomenon.
- The list of codes, when organised into a hierarchy, can be used to examine analytic questions such as the relationships between codes and comparison between cases.

Strauss and Corbin (1998) list the reasons why coding is useful to researchers. Coding procedures, however simple or complex:

- build rather than test theory
- provide researchers with analytic tools for handling masses of raw data
- help analysts to consider alternative meanings of phenomena
- be systematic and creative simultaneously
- identify, develop, and relate the concepts that are the building blocks of theory

What to code

Coding is normally carried out on interview transcripts. It involves marking sections of text which the researcher finds to be related, for example where they are examples of the same phenomenon. In the past this would often be done using cards or physically cutting and pasting documents. Modern day researchers are more likely to use electronic storage to copy and paste sections of text. Dedicated qualitative analysis software packages have also been developed, which allow the researcher to store their transcripts and link selected sections of text together. One of the most popular, the NVivo package,

was developed by Thomas and Lynn Richards. As this is available in the University of Nottingham, along with training courses introducing its use, the writer chose to use this package. It should be noted, however, that unlike quantitative analysis, where computers can perform mathematical work, the software is not able to perform analysis itself, since it cannot interpret the text, merely facilitate its storage.

Knowing what to code is the first challenge a researcher faces when attempting to analyse and interview. Lofland and Lofland (1984) suggest the following:

- Acts: action in a situation that is temporally brief, consuming only a few seconds, minutes, or hours
- Activities: actions in a setting of more major duration – days, weeks, months – constituting significant elements of people's involvements
- Meanings: the verbal productions of participants that define and direct action
- Participation: people's holistic involvement in or adaptation to a situation or setting under study
- Relationships: interrelationships among several persons considered simultatneously
- Settings: the entire setting under study conceived as the unit of analysis

Similar advice on types of codes can be found elsewhere, for example Gibbs' (2007) list of 12 types of codes adds the following to the other six shown above:

- Strategies, practices or tactics
- Relationships or interactions
- Conditions or constraints
- Consequences
- Settings
- Reflexive codes

How to code

Coding is an iterative process. The first set of codes developed are likely to be very close to the data, while subsequent levels of analysis will abstract these until they form theoretical categories. Miles and Huberman (1994) suggest the first set of codes will be descriptive and involve little interpretation on the part of the researcher. These should lead directly to interpretive codes, when the researcher becomes more knowledgeable about the context, its dynamics and the 'complex web of motives' at play. Finally, the researcher is able to create pattern codes, at the stage where they have finally moved from describing to explaining the situation they are studying. Similarly, Gibbs describes descriptive codes, categories and analytic codes, which are produced as the analysis proceeds (Gibbs, 2007). Strauss and Corbin begin with open coding, then axial and finally selective coding, using different techniques at each stage (Strauss and Corbin, 1998). All of these authors demonstrate how the researcher moves from description of the raw data – the words of an interviewee for example – to the development of a theoretical framework which has explanatory power.

As Yin (2003) argues, data from a limited number of cases has value to researchers since it allows them to generalise their findings to theory. Coding allows the researcher to move from actual events, to a

contextual understanding and then eventually to propose findings which are applicable elsewhere. Glaser and Strauss (1967) describe how this would work when they make a distinction between two types of theory.

- Substantive theory is developed for a substantive, or empirical area of inquiry, such as a particular type of company or group of people.
- Formal theory is developed for a formal, or conceptual, area of inquiry, such as leadership or reward systems, which may be applicable to a number of different substantive areas.

Both of these are "middle-range" in that they are neither working hypotheses on the specific area of investigation nor all-inclusive grand theories which apply to everything. The different levels of coding, along with the choice of unit of analysis – described above in relation to case studies – should be used by the researcher to focus on an appropriate level of theory. In conjunction with the other methodological and philosophical considerations described throughout this section, this will allow the researcher to make an accepted contribution to knowledge.

Tests of quality

It has been argued that researchers should test four elements which contribute to the quality of their research. These are taken into account at either research design, data collection or analysis phases according to Yin (2003, p34).

- Construct validity: establishing correct operational measures for the concepts being studied.
- Internal validity (for explanatory or causal studies only, and not for descriptive or exploratory studies): establishing a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships.
- External validity: establishing the domain to which a study's findings can be generalized.
- Reliability: demonstrating that the operations of a study – such as the data collection procedures – can be repeated, with the same results.

Yin provides a guide to 'tactics' to be taken by researchers to address these concerns, along with the phase of research in which they should be addressed.

Tests	*Case study tactics*	*Phase of research in which tactic occurs*
Construct validity	• Use multiple sources of evidence	Data collection
	• Establish chain of evidence	Data collection
	• Have key informants review draft case study report	Data collection
Internal validity	• Do pattern-matching	Data analysis
	• Do explanation-building	Data analysis
	• Address rival explanations	Data analysis
	• Use logic models	Data analysis
External validity	• Use theory in single-case studies	Research design
	• Use replication logic in multiple-case studies	Research design
Reliability	• Use case study protocol	Data collection
	• Develop case study database	Data collection

table 2.8 – methodological tests in case study research (Yin, 2003)

As discussed above, Yin has been criticised for supposed positivistic tendencies. It has also been argued that the tests of quality he proposed are unsuitable or insufficient for qualitative research. A set of alternative tests have been proposed (Lincoln and Guba, 1985, Riege, 2003) for research using other philosophical paradigms. These are confirmability (equivalent to construct validity), credibility (internal validity), transferability (external validity), dependability (reliability). Riege (2003) lists a series of audits to be used for conducting these tests. Overall, the tests appear relatively close to Yin's proposal (indeed the terms used by Riege seem to be based on Yin's work) and the audits involve review of research by peers or informants at various stages.

Conclusion

This chapter has presented a discussion of relevant literature, allowing the positioning of this research in terms of epistemology and theoretical perspective, research strategy, methodology and methods. The philosophical position of this work is that the topics of investigation actually exist, rather than being socially constructed. This position was arrived at through the experience gained in the interviews, which revealed that each interviewee could only shed light on a part of the topic of investigation. An alternative position could have been to seek consensus, and attempt to 'add up' the responses of informants. This would assume that all informants are equally knowledgeable and that the statistical average of their responses would provide the answer to a research question. This is inappropriate, however, since most informants were found to have only a limited knowledge of their organisation out with their own area. Another approach could have been to assume the absence of a common reality, assuming the research

topics to be social constructs and each individual to be an entirely unique case. This was deemed inappropriate since the opportunities for generalisation, practical recommendations and, ultimately, useful contributions, was deemed to be inadequate.

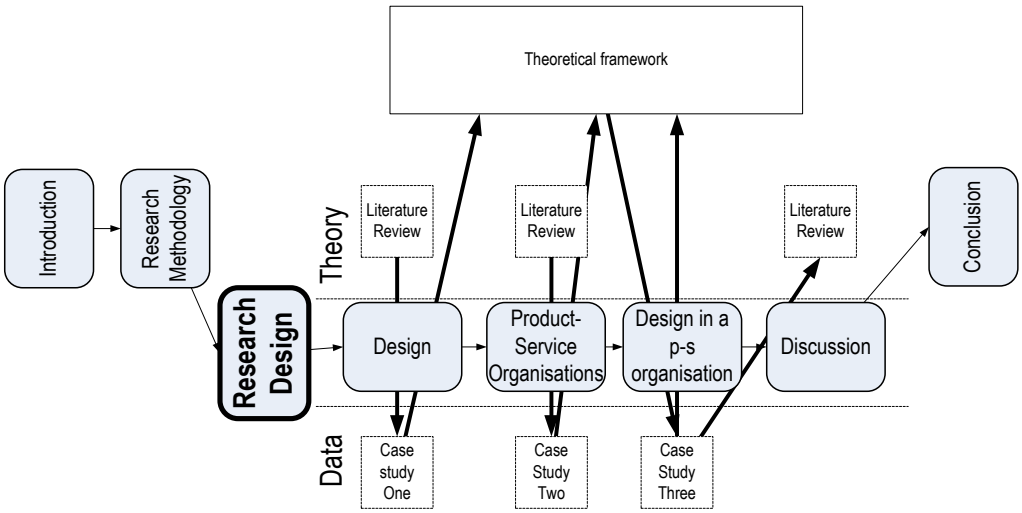
An abductive research strategy was chosen because it involves a back and forth movement between data and theory, allowing a theoretical framework to be developed iteratively, as literature and empirical work are used to build knowledge. A deductive approach would require all of the constructs to be well established, which was not the case for the topic of investigation. Meanwhile, an inductive approach could assume little or no prior knowledge. The deductive approach which was used allowed knowledge to be tested and built up through the three stages of the research. The overall topic of research was broken down into three topics, each of which was investigated in turn and contributed to the theoretical framework under development.

Finally, a case study methodology was adopted because of its ability to enable in depth investigation of topics in context. A survey, for example, is only appropriate when the constructs can be clearly explained and measured, which was not the case with 'design' and 'product-service'. The decision to allow themes to emerge from data, as opposed to forcing a framework was deemed suitable for enabling a novel contribution. Meanwhile, the comparison with literature, at key stages in the research, allowed the findings to be positioned and the contribution of this research to be established. The following chapter will describe the methods used in more detail as the research design is discussed.

Chapter 3
Research Design

> *"Not too many of us embark on a piece of social research with epistemology as our starting point…Hardly. We typically start with a real-life issue that needs to be addressed, a problem that needs to be solved, a question that needs to be answered. We plan our research in terms of that issue or problem or question."*
>
> (Crotty, 1998)

The research is about design, but this chapter is about the design of the project. Taking note of the methodological discussion in the previous chapter, here the approach taken in the research is outlined and the methodology for each phase of research is discussed. The chapter describes the methods and tools which have been or will be used to collect and analyse data. It describes the research process, before the following chapters discuss the outcomes of the research.



Following the previous chapter's discussion of epistemology and research methodology, this chapter focuses in more detail on the methods of the research. It describes the processes used to conduct the research in each of three main phases. Fitting within an abductive research strategy (Järvensivu and Törnroos, 2010) – also considered retroductive by Blaikie (2000) – the three phases involve examining parts of the overall research topic and moving progressively between literature and empirical work. The chapter gives an overview of the research on the role of design in business, product-service organisations and then an in-depth case study of the role of design in a product-service organisation. A summary of the literature reviews and their findings are given, before an explanation of what the empirical work sought to achieve and what it contributed to the overall theoretical framework proposed in this research. While each study can be seen as distinct and self contained, they should also be seen as part of the overall research, which has been broken down into smaller sections to enable an iterative and exploratory research process.

3.1 Research process

As chapter one intimated, this research started with very broad questions. Specifically, the researcher began with a literature review seeking to answer the question "what is design?" which had been assigned in the early phase of a research project. Subsequently, the scope narrowed significantly over time as this research has been conducted in several distinct phases, each of which followed logically from the its predecessor, but with more focus. An overview of the research is shown in figure 3.1, which indicates the outputs of each phase of research as well as the use of both theory and data. The first two phases began with literature reviews on the topics of design and product-service respectively, then used case studies in

conjunction with the literature, to develop theoretical frameworks. The third phase began with a largely inductive case study, which utilised the theoretical frameworks during the data analysis and then used a more focused literature review to compare the findings with relevant theory on integrated solutions and organisation design.

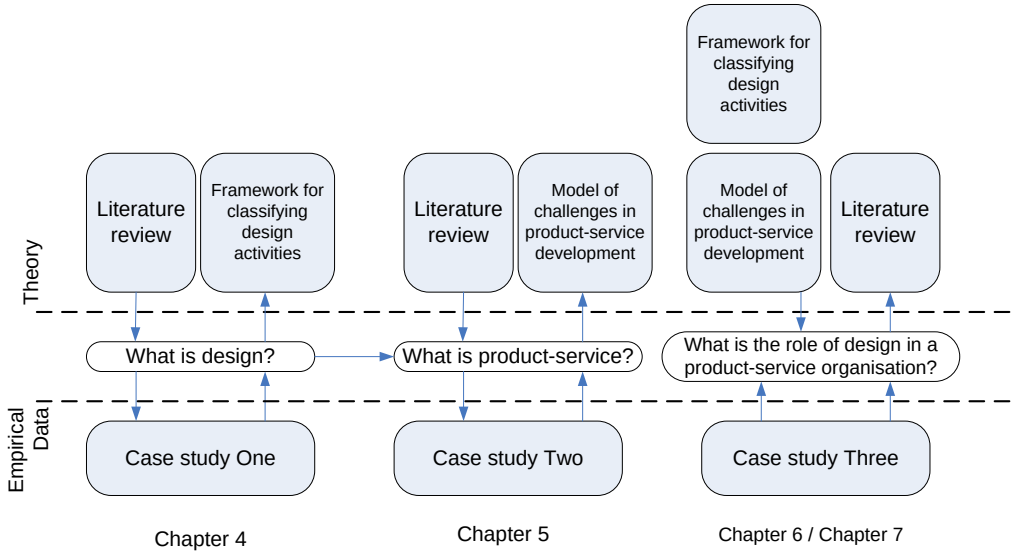


figure 3.1 – an overview of the research, showing where theory and data have been used, after Järvensivu and Törnroos (2010)

Case studies

Each of the three phases of research shown involved a case study. These are described in table 3.1, which uses Yin's (2003) classifications of the purposes of case studies. This demonstrates the narrowing of scope over the course of the research as the theoretical framework was developed and the research became more focused. Consequently, the number of companies in each study decreased as the studies addressed specific issues. The first sought to investigate a range of different companies in different sectors, to test the applicability of a method developed from theory with empirical data. The second focused on exploring specific organisational issues in two companies and, again, to test and to expand a theoretical model. The third case, on the other hand, was used to build theory from data, rather than testing theory. It was therefore more appropriate to use an in-depth case study, where a single company was adequate.

Case	Topic	Case Purpose	Case design	Companies	Company size	Company sector(s)
1	Design measurement	Exploratory	Multiple	6 companies	small to large	manufacturing to service
2	PS challenges	Exploratory	Multiple	2 companies	very large	aerospace and defence
3	Design in PS business	Explanatory	Single	1 company	very large	Aerospace

table 3.1 – case study designs, after (Yin, 2003)

3.2 Case study one – a method of measuring design effort

The first case study was conducted as part of the researcher's contribution to a collaborative project involving the Universities of Nottingham and Cambridge, as well as an advisory committee comprising academics from four other UK Universities. The project sought to develop national measures of design performance, which included a national survey of design spending in UK firms (Livesey and Moultrie, 2009). The researcher contributed to the early part of the survey development, through a review of literature on previous measures of design (and R&D) performance and efforts to develop and pilot a method of classifying design activities and measure spending on these activities. The work described in this thesis represents the parts of this project conducted personally by the researcher. The 'research team' referred to here comprises the academics involved in the project, who reviewed the methodology developed prior to the commencement of interviews. Colleagues from Cambridge also conducted parallel interviews at additional companies. Their cases are not discussed here, to ensure that the content of this document represents the researcher's own contribution, rather than that of colleagues.

Research questions

The background to the case study will be discussed in chapter 4. The result of the literature review, however, was a realisation that two gaps existed in research on the measurement of design's impact on business.

- Design is difficult to define: to overcome this problem previous research had focused on design in a particular context, such as product development (eg. Black and Baker, 1987) or industrial design (eg. Gemser and Leenders, 2001).
- Previous studies of design's impact on business had generally used objective, financial output measures of company performance. Despite this, they had generally failed to accurately capture financial input measures. The exception was a study which examined specific projects, which had been funded by the Design Council (Roy et al., 1998)

The research question, therefore, was

how can design be classified in companies and measured, objectively, in terms of inputs.

A requirement of this research was to both look beyond product design and to investigate a wider group of companies than product manufacturers. To this end, a group of companies was selected to span a range of organisational sizes and industry sectors. As shown in table 3.2, these included large service based and small manufacturing based companies, giving a range of perspectives.

Company	*Size*	*Industry*	*Interviewee role*	*Date*
CAMCAD	large	software development	Technical director	October 2007
Jones Engineering	medium	engineering services	Managing director	October 2007
Tiling House	small	retail of tiles	Managing director	November 2007
Expert Info	very large	market research and analysis	Facilities management executive	March 2008
Aeroservices	very large	aerospace and defence	Business architect	May 2008
Perfect Peach	small	web design	Managing director	June 2008

table 3.2 – pseudonyms of companies participating in case study one

Data collection

In each of the participating companies, an interview was conducted with a senior manager, who was required to have a good understanding of the technical side of the company's business. Although some financial information was requested from the interviews, it became clear on contacting financial managers, that they had little interest in and understanding of design. Prior to beginning the data collection, the method was developed by identifying the key issues and drafting a questionnaire and interview schedule. These were first discussed with a team of researchers and then piloted with acquaintances working in design related roles in their own companies.

Interviews

In each case company, respondents were first asked to describe, in their own words, the role of design in the company as a whole. This established the motivation for, and perceived benefit of, measuring their design spending. It also helped in verbalising their definition of design and the aspects of design that they considered important to their business. As will become apparent in the next chapter, definitions of design are numerous, so asking for the interviewee's own understanding was a useful starting point. On the other hand, the discussion of design was not permitted to become overwhelmingly abstract and an effort was made to keep within the context of the company's design activities. For example, in the software related companies, there was discussion over whether programmers – who interpret a brief and develop

code – should be considered to be designing. In response to the interviewees asking questions like "do you include programmers?" the researcher did not respond directly but either referred to the literature or asked the interviewee for their opinion. This was an effort to both reduce subjectivity and to gain more knowledge from the interviewee, rather than imposing opinions on them.

Questionnaire

Following the initial discussion, interviewees were presented with a questionnaire, based on a framework developed from literature and discussions with other researchers. The framework defined three main categories of design activities: 'product' design – referring to the company's central offering whether it be product or service; 'business-facing' design – referring to design which is not visible to customers, but influences value creation, such as processes or workplace design; and 'customer-facing' design – or any design which supports products, services or the company as a whole in its interaction with customers. The questionnaire listed some possible activities under each category and these were discussed with interviewees to understand what types of design their company conducted. The questionnaire requested estimates of effort, in terms of human and financial resources, devoted to these activities. The level of accuracy of these estimates varied greatly between the companies. In some, the Managing Director was able to look up figures in a book of accounts, in others, the numbers of people involved were so vast that no one individual could easily respond. The figures themselves, however, were of less immediate concern than understanding the process by which they could be arrived at in each company. Participants were asked to comment on the viability of producing financial estimates based on consideration of departmental budgets, resources engaged in design and activities that could be considered as design.

Interview topics

The interviews were 'semi-structured'. The questionnaire described offered some structure, while the rest of the interview was allowed to be flexible in order to investigate topics that were of interest in each individual company. A list of topics was, however, used to ensure that key issues were addressed. These were not asked as direct questions, in any order, but were used to guide the interview:

- How are costs calculated?
- How are overheads accounted for?
- What design is conducted in-house and why?
- What design is outsourced and why?
- What is the role of design in the business?
- What is the role of design in the market?
- Who has responsibility for design (people/departments)?
- What are the major design costs?
- What hidden design costs can be identified?
- How could design be measured in this company?
- What barriers to measuring design are there in this company?
- What is the relationship between design measurement and business performance?

Data analysis

All interviews were recorded and transcribed, before being used to write a case record. The case records followed a template, giving descriptions of the companies under the following headings:

- Company background – general information about the company, its history and its products
- Market and industry issues – unique aspects of the company's context which influence their design activities
- Design work – what types of design are done and by whom
- Questionnaire – describing any comments on the questionnaire itself, to improve the data collection method
- Recent changes – trends related to customers, competitors etc which influence design activities
- Role of design in the company – how the company and the interviewee view design and its contribution

These headings addressed the current situation in the company, with regards to identifying the design activities within the company. They also concerned the unique aspects of the industry or customer requirements which caused the company to differ from others. Finally, the case reports highlighted recent trends in the company, which affected the nature of its design activities. In addition to a case report, a graphical representation was made of the companies' design effort, in each of the categories defined within the questionnaire. An example is shown in figure 3.2, demonstrating the division of each of the three categories of design into two sub-categories. As the estimated spending figures given could not be compared directly, the researcher made estimates of the relative design effort in each category, based on the evidence given by interviewees. The aim was to follow a similar approach to Roy and Riedel (1997) who classified projects by the role of design and innovation, according to seven different categories and using three levels for

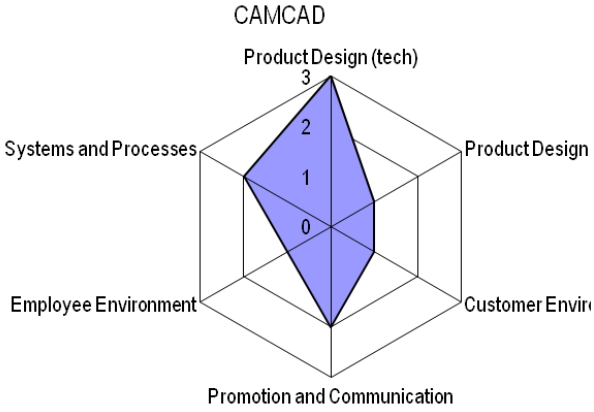


figure 3.2 – example of graphical representation of design effort

each category. In this case, although the levels of effort are not accurate, they give a means of comparing the relative efforts of different companies. For example, this company's effort is mostly on technical product design, with much less on the design of the user experience of their products, or the design of environments for customers.

Case study design

Following Yin's recommendations, the research was designed with consideration of five aspects, as shown in table 3.3. This summarises the logic behind the research design and indicates the chain linking research questions to the other aspects of the case study, up to the plan for analysing and interpreting data.

Research Questions	How do businesses use design? How can a business measure its design effort?
Propositions	Design is valuable to businesses, but they do not recognise all of the design activities they undertake. Identifying and measuring design effort will be the first step in understanding design's contribution to business performance.
Unit of analysis	Individual companies are analysed, using information from a key informant with an understanding of the issues addressed.
Logic linking data to propositions	The range of design activities in the different companies and the establishment of universal categories for classifying them.
Criteria for interpreting findings	A set of categories was developed prior to data collection. Interviews were structured around filling these categories with specific activities.

table 3.3 – the design of case study one

Yin also identifies the most common concerns about a case study's methodological approach which must be tested. The four aspects which Yin states should be tested are summarised in table 3.4, along with the recommended 'tactics' which were selected to address each of these tests.

construct validity	A chain of evidence was established, from transcript to case report to graphical representations. Results were presented to a research team.
internal validity	Yin states this is not a concern for exploratory studies, where no causal relations between variables are claimed.
external validity	Replication logic was used, by repeating the same process with a number of companies, chosen for theoretical reasons - giving a range of size and sectors.
reliability	A case study protocol, including questionnaire and a list of topics was used. This was agreed with the research team to ensure colleagues conducted similar interviews.

table 3.4 – tests of case study methodology and tactics used in case study one

3.3 Case study two – design challenges of product-service

Following the first case study, the increase in service offerings and the apparent relationship with design activities was identified as a topic of interest. This stimulated a review of literature seeking to understand what a product-service transition involves and how product-service organisations can be understood. Additionally, previous work conducted on a similar topic (CE-NET, 2004) was used as a starting point to structure the understanding of product-service organisations. The literature review covered articles from several different disciplines, including operations management and marketing, as well as incorporating texts written for academic (Neely, 2007), political (White et al., 1999, Mont, 2000) and practitioner (Foote et al., 2001) audiences.

Research Questions

Most of the literature was found to focus on case studies of small projects, concerned with environmental and social aspects (Baines et al., 2007). This meant there were gaps in the literature which presented an opportunity to make a contribution to knowledge, by investigating the issues in the large and successful organisations which were known to have implemented a product-service approach. Two notable gaps were identified in the literature, which related to design and management implications of what were referred to as "product-service systems" (PSS, e.g. Mont, 2002).

- The complexity involved in combining products and services may require new capabilities and ways of working, which demand collaboration with external partners. How to manage the resulting organisational complexity is not adequately addressed in the literature.
- Business models which rely on integrated product-service systems may not function effectively with existing products. How products should be designed to ensure their suitability as part of a product-service offering is not given adequate attention in the literature.

The research question, therefore was

Why do companies make a product-service transition and what are the implications and challenges of designing and delivering product-service offerings?

An overview of the research is shown in table 3.5, which demonstrates the approach taken in both the literature review and the empirical data collection which was used to address these research questions.

	Literature Review	*Data Collection*
Objective	To relate findings of a previous project (CE-NET, 2004) to literature on product-service development.	To analyse practical examples in order to illuminate and develop the theoretical framework.
Methods	Multidisciplinary review of literature related to PSS; identifying linkages with organisational collaboration.	Interviews and public documents were analysed with respect to the organisational challenges faced in developing PSS.
Findings	1. The common theme which connects product-service and organisation in the literature is the creation of value for customers and stakeholders. 2. The organisational dimension of PSS is not adequately addressed.	The cases highlight that a transition from manufacturing and selling products to delivering value through PSS requires new capabilities. PSS development therefore demands consideration of the organisational complexity and decisions on how to access these capabilities.
Original Contribution	Three streams of literature were identified and presented as different approaches to value creation through product-service combinations. The PSS literature is contextualised within the literature related to service marketing and operations management.	Organisational implications of PSS were elaborated, whereas cases in the PSS literature focus on the design and development of individual PSS, rather than the wider implications for an established business.

table 3.5 – overview of literature review and empirical research for case study two

Data Collection

In order to address the research questions, two organisations were selected for an exploratory case study. As recommended by Eisenhardt (1989) as well as Glaser and Strauss (1967), the organisations were chosen for their ability to extend existing theory in addressing the two questions above. The two organisations offered a high degree of organisational complexity along with having extremely high technical complexity in their products. Company A is a very large, UK based defence contractor, responsible for some of the most technologically advanced products in the world, which are now delivered to customers (principally the UK's Ministry of Defence) as part of a service, with payment based on delivery of 'availability' of products or 'capability' to achieve a specified objective. Company B is a very large UK company, operating in several areas, but most known for its power solutions in the civil aerospace sector. A number of different sources of evidence were used to write case reports, investigating the unexplored implications of PSS. Firstly, a great deal of information is available about these organisations in the public domain, for example articles in publications such as the Financial Times and The Economist. Secondly, a senior manager in company B delivered a lecture, in February 2008. Finally, interviews with informants from the two companies were used as an opportunity to ask direct questions and to confirm conclusions made from analysis of literature and data. These interviews were focused on the design activities within the organisation, but with a particular emphasis on how the range

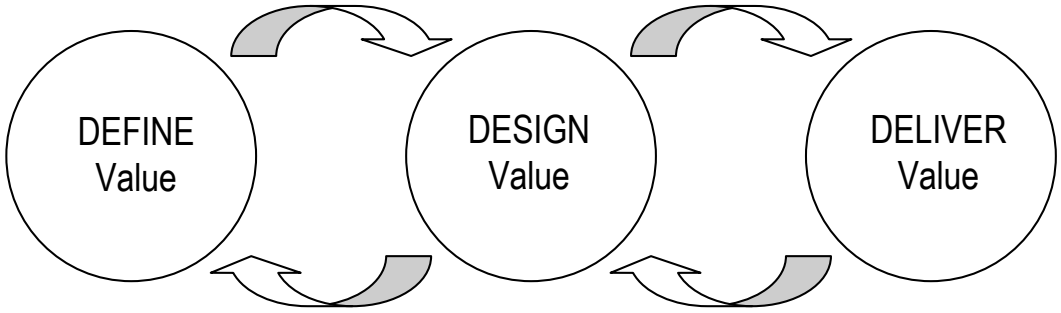
of activities had changed with the increased emphasis on PSS. They helped to develop an understanding based on the perspectives of the interviewees, who were well placed to comment on the issues addressed.

Data Analysis

Various issues emerged which were consistent with the literature, but added somewhat to previously published research. For example, the increasing use of external partners to deliver required capabilities (and the requirement for military and civilian collaboration) or the changing demands on products, such as increased reliability and reduced weight, were deduced from the interviews. A theoretical framework was developed, mainly based on the literature review, which allowed the issues from the interviews to be analysed. This follows Miles and Huberman's (1994) recommendation to identify the key elements in the study and suggest how they interact, regardless of how exploratory the study may be.

The process was iterative and involved a number of main stages. Firstly, recent articles related to the topic of product-service were reviewed and common themes were noted. Secondly, influential articles from previous literature were identified by following the citations of the more recent articles. Again, the common themes and concepts, were noted. The themes identified were presented and discussed with colleagues, who contributed their practical experience and knowledge from past research to help in shaping the framework. The framework was then presented to a wider audience, through conferences to build confidence in its value. The framework, which will be described in chapter 5, consisted of three high-level stages in the process of creating and delivering PSS. The framework is shown here in figure 3.3, along with the list of challenges which was eventually developed. These challenges combine the understanding gleaned from the literature review process as well as the evidence of the case studies which will be presented in chapter 5.

Firstly, the 'value' or benefits which customers require of the PSS is established. Secondly, the means of creating this value, in terms of the product, the service and the organisation of collaborating partners, is designed. Finally, the delivery of the PSS must be managed to ensure consistent fulfilment of customer requirements, or uninterrupted access to desired value. Using the case companies as a source of evidence, the three stages were defined in more detail, resulting in 6 specific challenges to be addressed by companies wishing to create PSS.



Defining the value proposition which will satisfy customers Estimating the cost and assessing the risks involved over the lifetime of the service agreement.	Designing the integrated system of products and service which create the defined value. Designing the organisation in terms of capabilities required to complement the core competencies of the firm.	Identifying, selecting and managing the network of partners which jointly deliver value. Defining performance measures and managing trade-offs to ensure quality and access.

figure 3.31 – a framework for PSS design challenges, from case study two

3.4 Case study three – aero-engine case study

The final case study built upon the findings and outputs of the first two, through an in-depth investigation of product-service design in a single company. This study was conducted as part of a project aimed at developing the approach to measuring the effort devoted to different categories of design activities in large companies. Case study one was somewhat limited in that it involved studying a company from the perspective of one individual, under the assumption that the informants selected would have a complete overview of the entire company and its activities. In contrast, case study two revealed that one individual in a very large company would have only limited awareness of the whole company and, only specific aspects of the company, such as those under investigation, could be studied from one person's perspective in such large companies. Case study three, therefore, expanded the approach used previously by using a total of 23 interviewees in a very large company. The company was selected pragmatically, since access was afforded by contacts within the organisation. The selection was also appropriate on theoretical grounds, since the company has been widely cited as an example of a successful product-service organisation.

Research questions

This case study sought to examine the design activities in a large product-service organisation, focusing on the nature of the offerings designed, the design process used to design them, the structure of the organisation which carries out the design and, overall the role of design in the organisation. The research questions guiding this study were, therefore:

- How does a product-service transition take place and what is its outcome?
- How are the products at the heart of a product-service offering designed?
- How is the organisation structured to develop product-service offerings?
- What is the role of design in a product-service organisation?

Case study design

As with case study one, Yin's (2003) recommendations for designing the case study were followed. As shown in table 3.6, the research questions guided the selection of other elements in the case study's design.

Questions	How does a product-service business use design?
Propositions	Offering a service will alter the requirements on product design, as well as increasing the requirement for 'business-facing' and 'customer-facing' design.
Unit of analysis	The case is a very large company, with embedded units of analysis - individuals, working within different functions within the case company.
Logic linking data to propositions	The data from individuals relates to different categories of design activities and therefore each set of data would reveal how different design activities were affected as well as the role of design overall.
Criteria for interpreting findings	Using the frameworks developed in the previous studies, the design activities reported were classified as product, customer-facing or business-facing and falling within the stages of defining, designing or delivering value.

table 3.6 – case study design for case study three

In this study, the researcher also used Eisenhardt's (1989) process for theory building from case studies, as well as Strauss and Corbin's (1994) methods for grounded theory development. Both of these approaches restrict the researcher's use of literature in the early stages, but the researcher felt this study was less reliant on an early literature review, unlike case studies one and two. having studied the literature previously, the background reading had been done, but this was put aside to some extent, to avoid missing issues emerging from the data, as Glaser and Strauss (1967) warn. The benefits of the grounded theory approach, include the ability of the methodology to generate theory which is closely related to real life situations which are studied, so the theory should be 'grounded' in the data. This was seen as important in order to create knowledge on practical issues which were not previously explored in the literature.

Data collection

Data were collected using semi structured interviews, which were based on the method developed in case study one. As before, the aim of this study was to understand the range of design activities, but in this case, each individual was asked about the activities in their own area, rather than the company as a whole. Achieving measures of design effort – at least in absolute terms such as cost of design on project x – was seen as less important than understanding the activities and, particularly how the change to a product-service business model had affected these activities. The interviews began with the interviewee describing their area of the business and what their function involved. They were then asked to identify the main design activities in their area. To stimulate discussion, the researcher used a diagram showing the categories of design formulated in case study one, to help convey the breadth of design activities being considered. This was considered by most of the interviewees to be general enough to be acceptable and allow them to respond. In several cases, however, the interviewees made clear that they were discussing activities which the researcher regarded as 'design' but for them, only the engineering

related design activities should be given this name. In fact it was noted that, particularly for those in an engineering related function, the words design and engineering were considered synonymous. Recognising this, the researcher began using terms such as “technical” and “non-technical” design, which were more in keeping with the culture of the company. It was important to investigate the non-technical design and other activities not normally labelled as design since this study sought to identify silent design activities. To this end, accessing multiple perspectives and, particularly, interviewing non-engineering personnel was extremely valuable.

Interviewees

Interviews were conducted with managers from a range of different areas of the company. Initially, contacts were mostly involved in supply chain functions, but were used to provide access to other areas of the company. For example, one contact, based in one of the company’s European locations, arranged a two day visit, which enabled access to the company’s operations on the site. This trip was particularly useful since it was easier to understand the complexity of the company’s design processes in the smaller and more concentrated facilities. The UK based operations are more dispersed and, since they are involved in much larger projects, staff are perhaps less aware of all the activities conducted by their colleagues in other areas of the business. In total, 23 individuals were interviewed, in the UK and Europe, as shown in table 3.7.

Interviewee	*Job Title*	*Area*	*Date*	*Location*
1	Executive	Supply Chain	November 2008	UK
2	Executive	Design	December 2009	UK
3	Supply Chain Manager	SCU 1	April 2009	UK
4	Manager	SCU 2	April 2009	UK
5	Supply Chain Manager	SCU 2	April 2009	UK
6	Analyst	SCU 3	April 2009	UK
7	Logistics Manager	Repair and Overhaul	April 2009	UK
8	Supply Chain Manager	SCU 3	April 2009	UK
9	Supply Chain Manager	SCU 3	April 2009	UK
10	Manufacturing Manager	SCU 3	April 2009	UK
11	Logistics Manager	Repair and Overhaul	April 2009	Europe
12	Purchasing Executive	New Product Development	April 2009	Europe
13	Manufacturing Engineer	Design	April 2009	Europe
14	Chief Engineer	Research and Technology	April 2009	Europe
15	Supply Chain Executive	New Product Development	April 2009	Europe
16	Group Leader	Testing	April 2009	Europe
17	Executive	SCU 4	April 2009	Europe
18	Executive	Design	April 2009	Europe
19	Executive	Logistics	May 2009	UK
20	Executive	Logistics	May 2009	UK
21	Executive	Logistics	May 2009	UK
22	Supply Chain Manager	SCU 5	Apr 2010	UK
23	Executive	Marketing	Apr 2010	UK

table 3.7 – a list of interviewees in case study three

A theoretical sampling approach (Glaser and Strauss, 1967, Eisenhardt, 1989) was taken to identifying interviewees, with contacts helping to identify colleagues who could shed light on areas where data were lacking. This involved selecting interviewees according to their ability to shed light on issues identified during analysis, which ran concurrently with data collection. While this does not prevent planning the research in advance, it does mean that the researcher must be flexible in their approach and responsive to the data as it is collected and analysed. The second key element of grounded theory is the use of 'constant comparison'. This was achieved by reflecting on the findings from each interviewee and systematically comparing them to the others, to develop a picture of the overall situation. For example, it became apparent that operational staff had little or no contact with customers, meaning a key part of the design process could not be understood. Through contacts in the company, it was possible to identify an interviewee from the customer-facing units. They act as an interface between the organisation and customers, but are regarded as an internal customer for whom products are developed and produced. After other parts of the organisation and their responsibilities in the design process had been explored, the CFBU was a gap so an interviewee was identified as a source of data on this area.

Analysis

All of the interviews were recorded and then transcribed by the researcher. The process of transcription was valuable in re-acquainting the researcher with the interviews and in beginning the analysis. Due to the timing of interviews, with some in the same week or even the same day as others, it was not possible to fully analyse each interview before commencing the next one. It therefore became necessary to do most of the transcriptions and coding in batches. Analysis of interviews was conducted using the NVivo8 software, which offered a useful tool for organising data in a single file. The software was used to organise the codes which the researcher generated from interview transcripts and to allow these codes to be combined and updated. The coding procedures in grounded theory are used to understand the meanings behind what the interviewees say, however

> *"...these procedures were designed not to be followed dogmatically but rather to be used creatively and flexibly by researchers as they deem appropriate."*
>
> (Strauss and Corbin, 1994, p13)

With this in mind, the researcher adopted a flexible approach, but followed a similar, if less strictly structured process to that prescribed by Strauss and Corbin. This involved open coding, with codes emerging from the analysis and a process of refinement to organise the codes and reduce their number into a manageable structure.

Open coding

When coding qualitative data, the researcher can begin with a list of topics and highlight any places in the data which relates to these topics, or allow the codes to emerge from the data. In either approach, the codes are very flexible and are certain to change as coding proceeds, as Miles and Huberman (1994) recognised:

> *"Whether codes are created and revised early or late is basically less important than whether they have some conceptual and structural order."*
>
> (Miles and Huberman, 1994)

Following Strauss and Corbin (1994), coding began with a close reading of interview transcripts, to identify the key issues. This was done by reading each line of text and labelling categories of things which the interviewee was found to be talking about. This is a time-consuming early step which requires intense scrutiny of almost every word. It is referred to as 'open coding' and begins with labelling everything, before "digging deeper" (p109) to discover categories and proceed further. Following the advice to "categorise richly and to code liberally" (Richards and Richards, 1995), two interviews were selected which were expected to contain the largest number of categories. These were one of the German and one of the British interviewees, who were among the most senior or who discussed the widest range of topics. This allowed specific themes to emerge which were expected to be relevant in the other interviews. For example, in the notes made by the researcher during analysis of one of the interview transcripts, the following appears:

> *There is one passage in particular (line 43 - 52), which I find interesting because it talks about integration and suggests that integration itself is a design effort. At this stage I anticipate the theme of integration to be prominent.*
>
> (Analysis logbook, 12th August 2009)

Upon reading the passage referred to, a code was created for "integration" and the appropriate text, highlighted in the transcript, was linked to this code using the software. At the early stage, in the analysis of the first two transcripts, almost every passage of text generated new codes. These codes were either named directly by the interviewees in which case they were "in vivo codes" (Miles and Huberman, 1994, Strauss and Corbin, 1994) or were named by the researcher, through interpretation of the transcripts.

Organising codes

As described above, one of the first codes generated was "integration", since this was seen to be an important topic which the interviewee talked about. This code was later expanded when other examples of integration appeared. These included a code for "technical integration", referring to the integration of components or modules of a product at the design stage, and "supply chain integration", referring to the

integration of suppliers, in parallel to the component design. In subsequent passages and when reading subsequent transcripts, any text which was seen to concern one of these topics was coded by linking the text to the appropriate code. The next stage of analysis was to begin grouping them:

> *"once concepts begin to accumulate, the analyst should begin the process of grouping them or categorizing them under more abstract explanatory terms, that is, categories."*
>
> (Strauss and Corbin, 1994, p114)

After reading and coding the first transcript, there were approximately 55 codes and these were grouped into a total of 9 categories, with 5 codes remaining that could not be grouped with any others in a hierarchy, these are listed in table 3.8. In the NVivo software, the terms used are “tree nodes”, for hierarchically grouped codes and “free nodes” for those which were not attached to a group. This means that the code titled “integration tasks”, for example, contained codes for “supply chain integration”, “technical integration” and “programme integration” at this stage.

"Tree nodes"		*"Free nodes"*	
1	Certification	1	Impact of Product-service
2	Division of labour	2	product characteristics
3	Innovation	3	providing capability for design
4	integration tasks	4	rational risks
5	NPI	5	Technical v Non-technical
6	PILM		
7	Programme Management		
8	Supply Chain Units		
9	What is Design		

table 3.8 – codes generated from first transcript

The second of the two selected transcripts was coded, using both the existing list of codes and adding to it where new issues arose. The following observation was made by the researcher about integration during this stage:

> *“the theme seems to emerge strongly, with at least two individual roles - Master Scheduler and Satellite Engineer - being quite clear examples. The interviewee has given a lot of description of these roles which calls for closer analysis later. Additionally, there are departments, such as FSO or Service Engineering and a database which are identified as a means of sharing knowledge and experience.”*
>
> (Coding memo, 15th August 2009)

This note made use of an important method in coding, namely the use of memos to explore the data and generate meanings. In this case, the note concerns individuals who carry out some kind of integration task. In addition to coding, which involved grouping and labelling sections of interview transcripts, these memos were one of the first steps in generating ideas in the analysis process. Integration of products and services at the design stage is of course an important topic in this research, but at this stage the idea of design having the role of integration began to emerge. The description above indicates how concepts collected during coding of different interviews had begun to develop.

Refining codes

The memo above also highlights that new codes were still being identified in the second transcript, in addition to new material being linked to the previously identified codes. Following the analysis of these first two transcripts, a more rapid approach to coding was used, as recommended by Miles and Huberman (1994). With each of the remaining transcripts, some new codes were developed, but most of the text could be linked to the existing codes. This meant that the number of new codes for each transcript steadily decreased.

Once all of the transcripts had been coded, the next stage was to refine these codes in order to reduce them to a more manageable number and to ensure that similar topics were brought together. This involved the content of each code being examined in order to group or combine similar or related codes, turning 'free nodes' into 'tree nodes'. For example, each code would have passages taken from several different interviews and in many of these there was some overlap, where the same passages of text were found to appear in more than one code. Those codes which cited the smallest number of interviews were the first to be merged into other codes that used the same passages. The codes were refined several times as further interviews were carried out and the constant comparison of data was used.

Reliability

To test the reliability of codes, two methods were adopted. Firstly, preliminary versions of the case study were prepared, presented and discussed. Most notably, a paper based on this case was presented at the EurOMA conference (Beltagui et al., 2010b). Attending conferences and workshops also enabled the researcher to compare the findings with the research of others who had studied the same company or other product-service organisations. This helped to maintain the relevance of the case study and ensure that there was new knowledge emerging from the analysis. It also ensured that the analysis was reliable since there was an opportunity to discuss the researcher's understanding with others. The second method was to check the reliability of codes, as described in chapter 2, by inviting independent researchers to review the codes and attempt to code a small sample of the total data set. Three interviews (13% of the total) were given to two independent researchers, both of whom had been involved directly in interviews with Aero-Engine Co. and analysis of data related to the company and its product-service transition. They were also provided with a list and description of the researcher's codes, which are shown table 3.9 and asked to code the data in this structure.

1	**Context and background**		
1.1	Nature of the market		The market(s) which the company operates in and the types of requirements which customers demand as well as indicating the steps customers go through when purchasing a product
1.2	Technology		The development of technology and its importance as a source of competitive advantage and a defensive barrier to entry
1.3	Innovation v reliability		The tension between the company's image of reliability and innovation and how this is tension is manifested throughout the organisation
1.4	Minimising change		A desire or requirement to reduce the amount of novelty or change throughout product development and the reasons why this occurs
	1.4.1	Variations	Differences in engine usage, for example between customers, which demand changes to the design of components, engines, supply chains etc.
	1.4.2	Costs	The cost implications of changes, which support the desire to minimise change
	1.4.3	Risks	Examples of where risks are taken and mitigated
1.5	Certification		The requirement for certification of various kinds - product, technology, supply chain etc - and how the requirement affects the organisation
2	**Product Development**		
2.1	NPI Process		The steps and stages involved in product development
2.2	Integration		Integration is seen by some as a type of design, this includes integrating people, processes, suppliers, components…
	2.2.1	Go-betweens	These are people, departments etc which make things run smoothly by integrating
	2.2.2	Integration tasks	These are activities or tasks which are required in product development and involve integration
2.3	Business Strategy		Strategic business decisions related to product development
	2.3.1	Business case	The relationship between the engineering and commercial (technical and business) considerations in development.
	2.3.2	Make v buy	Manufacturing activities and capabilities and the decisions on whether they are in-house or bought in

table 3.9 – the coding structure generated through data analysis in case study three

2.4	OEM v AM		A distinction is made between components produced for new products (OEM) and those delivered to repair shops for aftermarket (AM) servicing

2.5	Supply chain issues		The involvement of suppliers in product development and production, as well as the issues arising from their relationship with the company
3	**Product-service**		
3.1	Product-service transition		The history and implications of the company's "servitization" transition as described by interviewees
3.2	Product-service offerings		The business model and the nature of the offerings sold to customers
	3.2.1	Scheduled maintenance	Repair and overhaul services conducted at scheduled time intervals
	3.2.2	Unscheduled maintenance	Repairs conducted to correct or prevent unintended issues
	3.2.3	Condition monitoring	The equipment and processes used to track performance of products in use and how the data are used in service delivery
4	**Organisation**		
4.1	CFBU		Customer Facing Business Units and their interactions with customers in product development, production and service delivery
4.2	SCU		Supply Chain Units and their management of product design, development and maintenance
4.3	Project team		The team which oversees the design and development of a new product
4.4	Component IPT		Integrated Project Teams responsible for developing components
4.5	Business functions		The organisational structure of the company as a whole, including standard roles throughout the organisation
4.6	Culture		this describes aspects of the organisational culture

table 3.9 – the coding structure generated through data analysis in case study three

Design activities

Coding the interviews helped to develop themes and enabled an in depth study of the issues addressed. It also contributed to the identification of individual design activities which were classified using the frameworks developed in the two previous studies. The classification relied on the information provided by interviewees and hence cannot represent a complete list of design activities. By classifying activities reported by interviewees from different functions and perspectives throughout the company, it was possible to gain an overview of the types of activities involved. This can also be used as an indication of the design capabilities in the company and where they have been re-aligned, for example there is a suggestion of a change in the type of business-facing design activities, from designing manufacturing processes to designing supply chains, and an increase or planned increase, in customer-facing design activities.

The design activities were classified by category of design and stage of product-service value creation. As shown in figure 3.4, they were also classified by the customer for whom they were seen to create value – either the airframer which produces aircraft powered by the company's engines and with whom products are developed, or the airline which uses the engines and to whom services are delivered. This forms the basis for a framework to consider design activities and capabilities in the development of product-service offerings. The reliability of the researcher's classification was also checked with the assistance of two independent researchers. They selected a sample of the design activities identified by the researcher from analysis of the data. They were then asked to code these in stages, to answer the following questions:

1. Whether these qualify as design activities
2. What type of design activities they are
3. What stage of product-service development they fall under
4. Who the customer or stakeholder they benefit are

The reliability was calculated using Cohen's κ, as described in chapter 2, before the researcher's coding was reviewed, resulting in a greater level of agreement. This will be described further in chapter 6. A full list of the design activities identified from the case study, along with the categories they were coded in, is provided in the appendix.

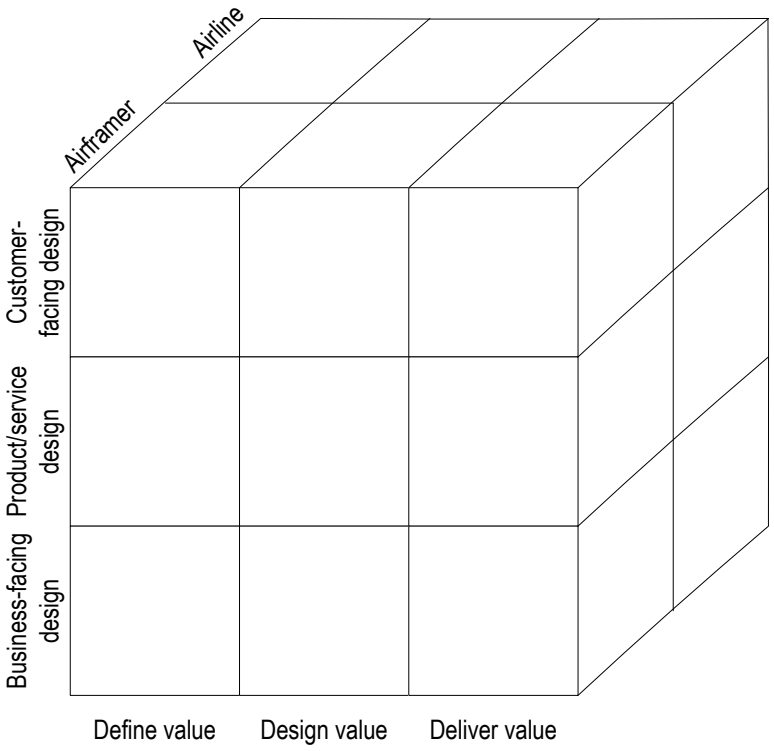


figure 3.4 – a framework for analysing design activities, stages of value creation and customers for whom value is created

Developing theory

The process described above was used to collect data, understand and combine this data and then produce new concepts related to the research questions, but 'grounded' in the data. Using the codes which had been developed and refined, the researcher identified key issues, some of which had not been anticipated. To clarify the contribution to theory, a further literature review was used, to focus on the key issues as they appear in the work of other academics. In particular, the integrated solutions literature (e.g. Davies et al., 2007, Windahl and Lakemond, 2010) was used to compare theoretical representations of product-service organisations with the case company and highlight departures from the existing theory. Additionally, some organisation design literature (e.g. Lawrence and Lorsch, 1967b, Galbraith, 2005) helped in analysing the significance of the findings related to the organisational structure and integrated teams.

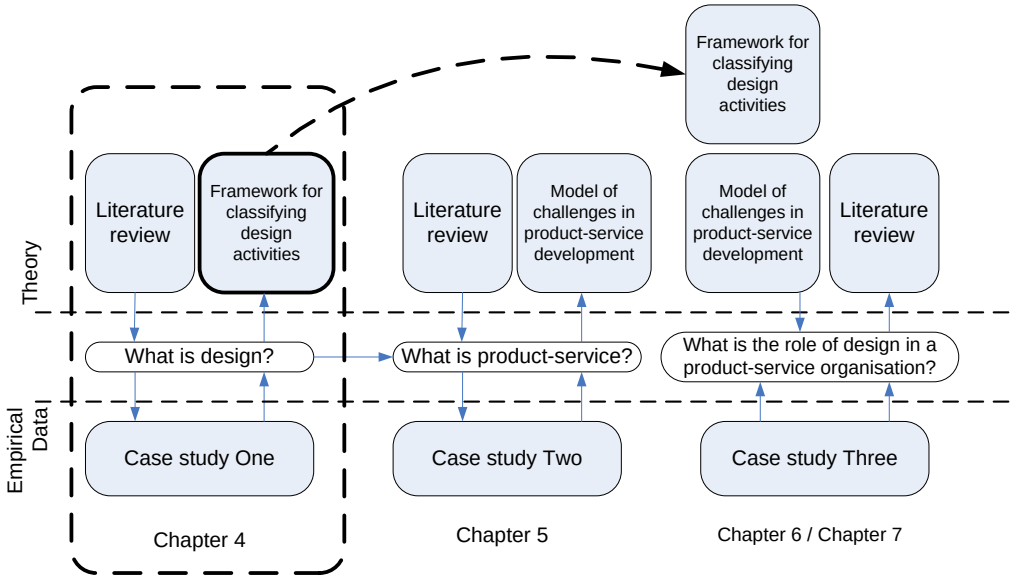
Chapter 4
Design (and its role in business)

> *"Any act of changing the world is an act of design, not just machine-tools, furniture or house design, but also the development of health care systems or legislation, all man-made changes affecting our lives are by design."*
>
> (Evans et al., 1982)

This chapter is concerned with the nature and role of design in business. It describes the outcomes of a project which was concerned with developing a means of measuring design effort in business. The chapter begins with a review of the literature on design and presents a list of previous academic studies which attempted to measure the impact of design on business performance. It then proceeds to a description of the writer's own research on the topic and ends with a proposed approach for the measurement of design effort in businesses. The case study research used to investigate this topic was described in chapter 3, the results are shown here, along with a description of how they led to the next stages of research.

Relevant publications

1. **Beltagui,** Pawar, Riedel (2009) *Design Leadership and the role of design in the firm*, 16th International Product Development Management Conference (IPDMC 09), Twente, Netherlands, 8-9 June.
2. **Beltagui**, Riedel, Pawar (2008) *Design Scoreboard – capturing design spending in firms*, 14th International Conference on Concurrent Enterprising (ICE 2008), Lisbon, Portugal, 23 - 25 June.
3. **Beltagui**, Riedel, Livesey, Demian, Moultrie (2008) What is design? – Design ScoreBoard briefing note 1, Nottingham: Nottingham University Business School. http://www.designscoreboard.org/documents/What_is_Design.pdf



This chapter explores the role of design in businesses. Design is a topic on which almost everyone has an opinion and an often unique understanding. In order to study the role of design in product-service organisations, it was first necessary, therefore to achieve clarity in the understanding of design and develop an approach which would facilitate further research. To this end, a review of literature examined different definitions and understandings of design, before a working definition was identified. Subsequently a theoretical framework was developed, which consists of a classification of design activities into three categories of 'product' related, business-facing and customer-facing design. The theoretical framework was validated through a multiple case study investigating its applicability in a range of companies. The framework allows companies from different industries to be compared in terms of their design effort, or the types of design they conduct and the resources devoted to them.

4.1 What is design

A major problem with most of the literature on design is that the basic starting point, a definition, is not agreed. Design can be a noun or a verb, that is, a product which has been made by humans may be referred to as 'a design', while the activity that produced this product is the act of 'designing'. Additionally, the word is now used as an adjective, as in 'designer' goods (Lawson, 2006).

The usage of the word in different contexts can differ, which makes it difficult to pin down a definitive meaning. "The word 'design' is applied to an extraordinarily wide range of activity including at one extreme something that could also be called 'engineering' and at another something that could be called

'art'" (Lawson, 2006). Nuclear plant design and wallpaper design (Kotler and Rath, 1984) are clearly different despite the similar names. Use of the word design often causes misunderstanding because

> *"…it includes disciplines ranging from engineering, product and industrial design to fashion, textiles, graphics, interiors, exhibitions and architecture"*
>
> (Walsh et al., 1992).

Design disciplines

There have been attempts in the past to understand design by classifying the different disciplines of designers. This is almost impossible to do when it becomes clear that changes in changes in social and technological conditions result in the emergence of new disciplines over time, as shown in table 4.1

Freeman (1983)	**Experimental:** prototypes, production drawings **Routine Design Engineering:** adapting existing technology to specific applications **Fashion Design:** aesthetic/styling, novel forms and shapes but no technical changes **Design Management:** planning and co-ordinating
Gorb (1990)	**Product Design:** including fashion **Environmental Design:** architecture, interior and landscape design **Information Design:** sometimes known as graphic design **Corporate Identity Design**
Design Council (1988)	**Product Design:** including products ranging from ceramics and toys to scientific instruments. **Graphic Design:** covering everything from corporate identity and packaging to magazines and film **Interior design:** including shops, buildings and exhibitions **Fashion and textiles:** ranging from clothing and carpets to jewellery
Design Council (2005)	**Communications, branding and graphics** **Architecture/landscape** **New product development** **Industrial design** **Packaging design** **Engineering design** **Service design**

table 4.1 – classifications of design disciplines

Shirley and Henn (1988) divided all design into either graphical (two-dimensional) or product (three-dimensional) design and categorised these as shown in figure 4.1. A comparison with the table above demonstrates how things have changed. Several of the disciplines listed above, for example service design and multimedia design, are now more important for professional designers than product design (BDI, 2007). These would not fit into Shirley and Henn's classification, however, since they are neither two nor three-dimensional but may involve the design of intangible outputs.

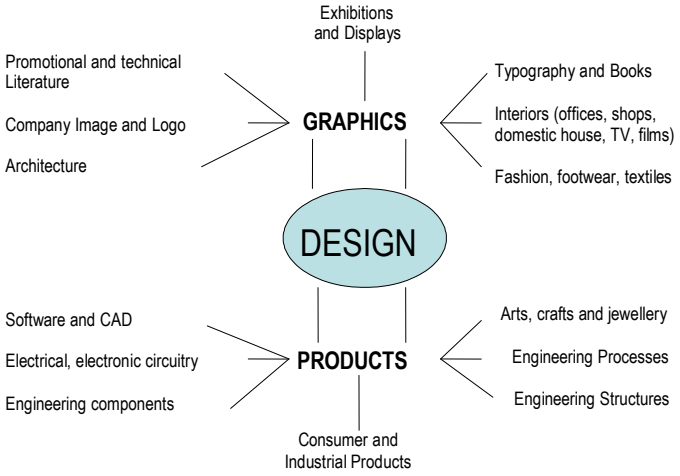


figure 4.1 – a classification of design disciplines (Shirley and Henn, 1988)

The types of design discussed above are all distinguished by their outputs. In this way, one can distinguish between the work of an architect or an engineer since they design different things. Another way of distinguishing between types of design is by the process used and the knowledge required. Tether (2006) attempted a classification of design by the process and output, as show in figure 4.2. Here the types of design require a range of different types of knowledge.

> *"…from the rational, calculative knowledge utilised by engineering designers, to the expressive, subjective knowledge of fashion and graphic designers."*
>
> (Tether, 2006)

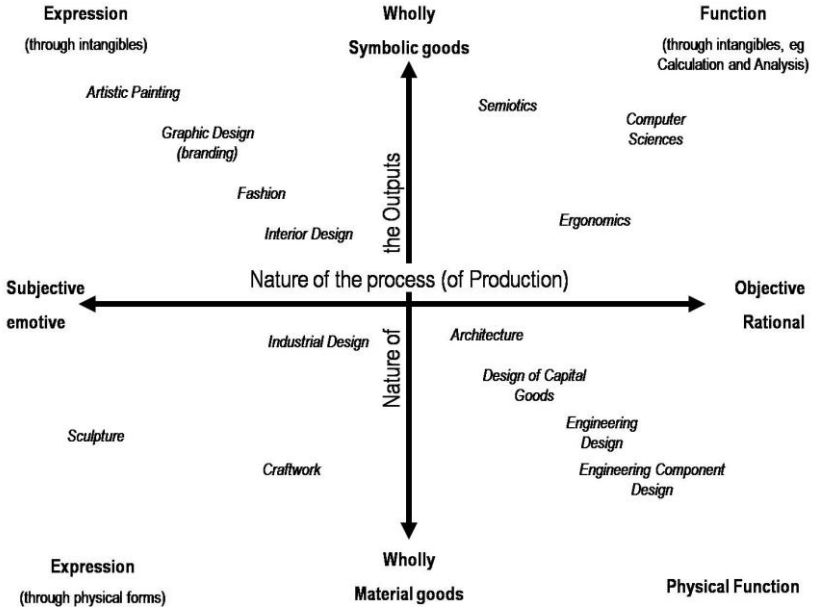


figure 4.2 – classification of design disciplines (Tether, 2006)

The aspects of design range from subjective and emotive forms to objective, rational varieties and the vast range makes it almost impossible to pin down. What links them is the similarity in processes

followed in order to produce the different outputs. Despite all of the diversity in output, according to Gregory (1966) "the process of design is the same whether it deals with the design of a new oil refinery, the construction of a cathedral or the writing of Dante's Divine Comedy." Some would argue that writing the Divine Comedy is not an act of design, but this merely highlights the differences in opinion and the difficulty of reaching consensus.

Design processes

Among those that see design as a process, there is some level of consensus that there are three main elements: analysis, synthesis and evaluation. Evans et al (1982) describe a an early design conference in which the identification of these three elements was the limit of consensus. Beyond this each participant "defended their definitions of the peculiar nature of design as practiced within their own traditional professional boundaries such as architecture and engineering." Although the three elements are generally taken to be sequential, in that order, most processes show feedback and interaction, so the diagram in figure 4.3 is perhaps a better representation. Analysis of various design methodologies and processes will show different stages, emphasis and terminology, but these three elements are generally present in some form.

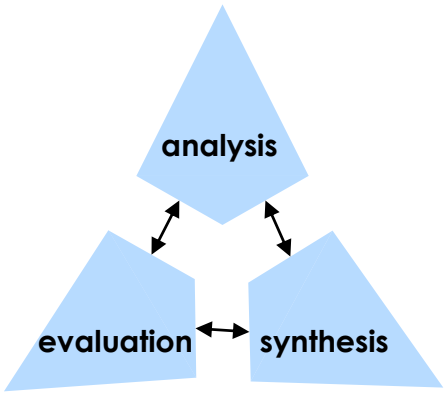


figure 4.2 – elements of design processes, in a non-sequential form (Lawson, 2006)

Archer (1965) was one of the first writers to describe design as a systematic process and specify activities to be carried out within this process. In referring to the output of this process, he gave three criteria for the activity of producing this output to be considered design:

- It should be "a prescription or model for a finished work", not the work itself
- It must be intended for "embodiment as hardware"
- It must include a creative step, rather than resulting from equations or selections

A universal definition remains elusive and the result of searching for one is generally the conclusion that design means different things to different people (Micklethwaite, 2002). In light of the brief review shown here, and the writer's experience in conducting this research, Archer's criteria seem the most useful in offering an understanding of what design is. Nigel Cross (2000) made a distinction between craft-based design and design in post-industrial societies, where the conceptualisation of a product is separated from its manufacture or production. Design can usefully be seen as the planning stage prior to production of

goods or delivery of a service. Whether the output is two or three-dimensional, tangible product or even an intangible service, its design is the creative, mental process which results in its implementation being planned. The actual implementation, however, is not normally considered to be part of the design process. The process also requires an element of creativity being added by human brains. There are, of course, exceptions to this rule, for example where the design process is largely analytical, for example when engineers design components in the aerospace industry. In such cases, creativity is bounded to a greater extent than, for example web-design or graphic design, yet the processes, at some level, are considered to be the same. The definition of design which will be adopted in this research is, based on Archer's criteria:

The creative process of developing a prescription or model to be embodied in a finished offering.

4.2 Design in the management literature

It is widely accepted that design is a valuable business function and one which can make a significant contribution to the performance of companies. Several studies over many years have aimed to measure this specific contribution, presenting a strong argument for the value of design (Hart et al., 1989, Hertenstein et al., 2005). It has also been recognised that design involves a way of thinking and an approach to problem solving (Lawson, 2006). There have been recommendations for business managers to make use of design thinking since at least the 1960s, when Herbert Simon wrote about its requirement in the 'artificial sciences' (Simon, 1996). Such recommendations can be found in the recent management literature, particularly in relation to the nature of education offered to managers (Boland and Collopy, 2004). Design can also be seen as a means of communication, which can be utilised in the relationship between a company and its customers. It has been noted that the 'design language' of products can convey meanings and that some companies manipulate these meanings through design (Verganti, 2006, 2009).

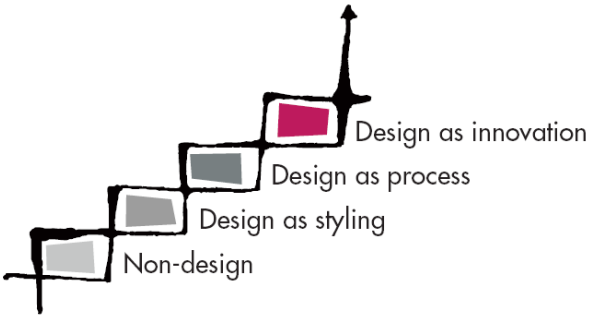


figure 4.4 – the Design Ladder: a hierarchy of 'design maturity' (SVID, 2004)

It can be seen that design as a business function, design as an approach to management and design as a means of non-verbal

communication are different, yet related subjects. Many companies manage their design function successfully without their managers using 'design thinking' in their leadership of the business. The role and significance of design varies between companies and its part in the leadership style of managers also differs greatly. An attempt to represent the differing roles hierarchically was conceived by the Danish Design Centre (2003) and is shown in figure 4.4, in the Design Ladder. At the lowest rung, design is not actively managed, although some design activities are present in every company. Further up the ladder, design is an isolated business function (styling) and then managed as part of a process. At the highest level of 'maturity', design is seen as a central, strategic function which shapes the direction of the business. This closely resembles the evolution of design's role in business proposed by Perks et al (2005a). While this evolution is observed in some companies, for many managers

> *"…an excessively narrow view of design hinders a broader, more strategic approach towards its management."*
>
> (Schneider, 1989)

There are arguments that design is misunderstood (Von Stamm, 2004) or neglected by "design illiterate" managers (Kotler and Rath, 1984). In some companies, however, design is valued by managers and is crucial to the success of the business. The management literature supplies examples of where and how design, design thinking or design languages have been of benefit to companies.

Design as a business function

Design was once described as a "competitive weapon for business" (Lorenz, 1986) in an argument that companies should employ more trained designers, to improve their competitiveness. Similar arguments have been presented by others, for example measuring the increased turnover resulting from an increase in design investment (Sentance and Clark, 1997) and measuring the commercial impact of employing external designers on projects (Roy and Potter, 1993). More recent studies have continued this work (Gemser and Leenders, 2001, Hertenstein et al., 2005) often with an assumption that design is a function, within product development, conducted by industrial designers. In fact, design affects the business in other areas outside of product development, as will be shown in this paper.

In many instances, the word design is used interchangeably with innovation or product development (Marxt and Hacklin, 2005). These are three closely linked, but ultimately different tasks within a business. Design's contribution to innovation is traditionally regarded as being in the development of products which utilise the outputs of research and development. This perhaps corresponds with the 'design as styling' rung of the Design Ladder. It can also be seen as a driver of innovation, as in Rothwell's (1992)

model of innovation as a central, unifying function, which bridges the gap (Walsh, 1996) between internal facing, and customer facing operations. Recent reports for the British and Irish governments (ICSTI, 2002, Cox, 2005) have both pointed to the separation of arts and sciences in the education system as a reason why individuals may have difficulty relating to people and technology. The ability to understand both what customers want and what the company's capabilities allow it to deliver is considered important for designers (Lawson, 2006). This makes designers' role in the business potentially very important.

The role of designers is perceived differently and has changed somewhat over time. Perks et al (2005a) charted an evolution in the role of designers, from being considered as merely stylists, to being an important player in product development. They considered that designers have now become leaders of NPD with a high strategic involvement, although how widely they are perceived as such can be questioned. Goffin and Micheli (2010) on the other hand, identified a gap between the perceptions of managers and designers with respect to the role of designers. Whereas the designers they studied considered themselves to be central to product development in their companies, their managers considered them to be just one of several equally important functions.

Lorenz (1986) presented case studies of a number of successful companies, highlighting how designers had contributed to their success. The impact of design, however, went far beyond re-designing these companies' products. Managers in companies such as Sony, Olivetti, Philips and even John Deere demonstrated an appreciation of design and its potential impact. In each of these cases there was a willingness to invest in buildings which would communicate the company's valuation of design. All of these companies employed renowned architects to design new headquarters. In each case, managers selected designers, either employed internally or contracted externally, and then trusted them with responsibility and freedom to be creative. What is clear is a managerial attitude which indulges creativity despite perceived financial risks. As Bolland and Collopy (2004) argued, "exotic methods of financial analysis do not create value" but instead managers require a "design attitude". Verganti (2009) identified such an attitude in the management of small firms in the North of Italy such as Alessi and Artemide. These companies belied their small size to create hugely successful, iconic products. Verganti's view is that the managers of these companies and in particular their encouragement and trust of designers was the key to their success. Similarly, Martin (2009) describes Hermann Miller, the successful furniture manufacturer and its approach towards the external designers which it commissioned to design award winning and oft imitated office chairs. Martin describes how the company's directors trusted designers to

create good designs, rather than being swayed by initially negative feedback from consumer focus groups. While customer feedback can be invaluable, customers are often unable to see beyond what they currently know, making it difficult for them to assess innovative designs.

Design as a means of communication

Innovation is often seen as the result of a 'market-pull' or 'technology-push' process (Dosi, 1982). Many innovations, however, do not result from market needs or new technology but as a result of designers manipulating existing technologies (Walsh et al., 1992, p27). The concept of design driven innovation has been proposed more recently (Mutlu and Er, 2003, Verganti, 2003), suggesting that 'design-push' should be added to the sources of innovation. Individuals who combine knowledge of available technology and awareness of market needs often fulfil the role of "technology brokers" (Hargaddon and Sutton, 2000). They utilise available technologies to create innovative products, so that innovation is not driven by R&D, but by design. Equally, while some companies are led by the market, designing according to the results of market research, others design first and then test their designs in the market (Kotler and Rath, 1984). Those companies which do so successfully are therefore able to predict and satisfy customer needs, which may not be made explicit.

Verganti (2008) considered that those companies which successfully innovate through design, do so through their ability to communicate with customers, using design as the 'language' of their interactions. He contrasted 'design driven innovation' with managerial theories which regard innovation as technology driven. He argued that a radical shift in meaning, as much as a change in function can lead to innovation. He cited the example of the wrist watch, which was regarded as a valuable item of jewellery, until cheap electronic wristwatches, manufactured in the Far East led it to be seen as a functional measurement instrument. An example of a radical change in meaning is Swatch's use of the watch as a colourful fashion accessory. Verganti's idea can be likened to Clark and Fujimoto's (1990a) identification of a "concept" which exists in every product and is present in every stage of its development. If the concept does not match what a customer expects, or the meaning is not consistent in the design language used, then the product may not be appreciated because it lacks "product integrity". They gave an example of two automotive companies, utilising similar 4-wheel drive technology in the development of new vehicles. While Nissan chose to incorporate the technology into a family oriented vehicle, Honda applied it to a model which was seen as more 'sporty'. Clark and Fujimoto attributed the success which Honda enjoyed with this technology to consistency of the concept and explain Nissan's relative failure by highlighting a

loss of product integrity. This means that the product's concept was confusing and that the technology in use was inconsistent with customers' expectations.

Traditionally, product development resembled a "relay-race" (Takeuchi and Nonaka, 1986), in which a project passed from one team to another, sequentially. Increasingly, however, product development requires teams to work concurrently. It is possible for these teams to lose sight of the end user and consequently fail to maintain product integrity. Clark and Fujimoto identified that in successful companies, a "heavyweight product manager" was employed, with control over all of the teams involved in product development (Clark and Fujimoto, 1990b). This individual should have a clear understanding of the product concept and ensure that it is not lost. They are required to understand customer needs and appreciate the meanings conveyed through the products which satisfy them.

Design as a way of thinking

Another perspective is that design is a way of thinking, which is utilised by anyone who "devises courses of action aimed at changing existing situations into preferred ones" (Simon, 1996). Herbert Simon viewed design as a requirement in all of the "sciences of the artificial" (Simon, 1996) – a range of disciplines which included medicine, architecture and business management. Boland and Collopy (2004) proposed that design thinking is of importance to all managers. They argued that managers are trained to solve problems through analysis, but lack the ability for synthesis which designers possess. Lawson (1994) was able to demonstrate by experiment that 'designers' and 'scientists' take different approaches to solving problems. The scientists in his experiment were more likely to analyse available information, to understand the rules and await the ideal solution to present itself. In contrast, designers proposed solutions and examined the results in a trial and error process, they were more focused on finding a working solution quickly. Schön (1991) described the idea of 'reflective practice' which views problem solving as a "conversation with the situation". The problem solver is not seen as a detached observer, making disinterested decisions as the result of analysis alone. Instead they are acknowledged as being within the problem they are solving and their actions as altering it. This requires 'reflection' on how the problem has changed before the next action is taken.

Design thinking, as proposed by these writers can be summarised as a problem solving approach which relies upon individual creativity. Many writers have contributed to debates on creativity and its source, for example presenting conflicting evidence on whether it is an inherent trait or an ability that can be gained (e.g. Weisberg, 1986, Azadegan et al., 2008). Such conflicts reflect a "deep paradox about the creative

process" (Swann and Birke, 2005) which requires creative people to be simultaneously extroverted and introverted and maintain a "delicate balance between obedience and disobedience" (ibid.). This presents a challenge to managers seeking the benefits of their employees' creativity while avoiding the inherent difficulties which come with such unconventional behaviour.

Roger Martin (2007) developed a concept of design thinking as an approach to managing a business. He described the knowledge funnel, in which different types of thinking are of use at different stages. He argued that successful design thinking organisations, such as Macdonalds, RIM, Procter and Gamble or Hermann Miller were all able to solve mysteries in their field, related to what strategies they could succeed with in their markets. They were then able to turn these solutions into well structured and repeatable processes to consistently and efficiently deliver profits. Then they sustained their success by seeking new mysteries and new solutions, rather than being stuck in the processes which would bring attractive, yet short term profits.

4.3 Design and innovation

The three topics discussed above are all to be found in the management literature and their presence suggests the importance of studying design in the business school context. In a business context, design can be seen as

> *"what links creativity and innovation"*
>
> (Cox 2005).

Although this defines a vague concept using two similarly ambiguous terms, it implies design as the business function which converts ideas (creativity) into profitable products and services (innovation). A diagram representing the linkages between creativity, design and innovation can be seen in figure 4.5, taken from a recent report to the UK government (Swann and Birke, 2005). Design is "at the very heart of innovation" (OECD, 2002) in a traditional view which sees it as the planning and specification of an innovative product prior to manufacture. Design can also be viewed as a driver of innovations which do not emerge directly from new technology (Walsh et al., 1992, Utterback et al., 2006).

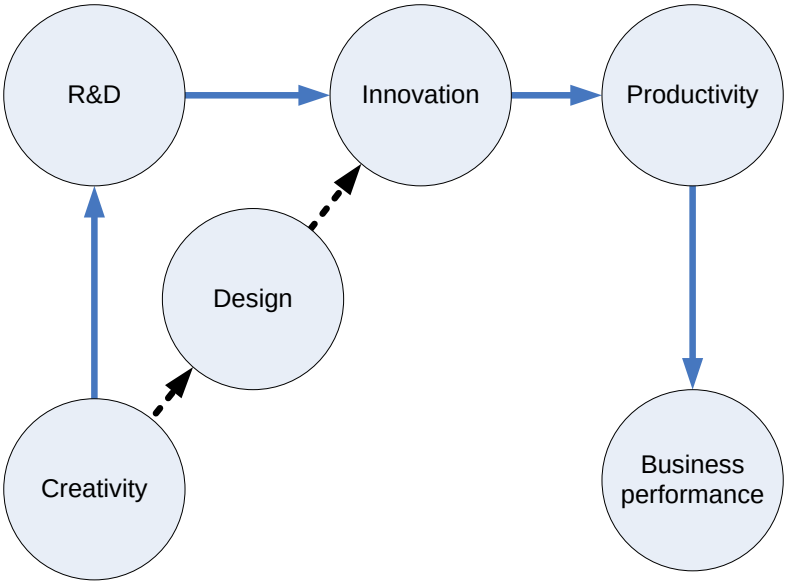


figure 4.5 – contrary to traditional innovation models, design, rather than R&D alone, can be a driver of innovation (based on Swann and Birke, 2005)

As documented by Rothwell (1992), models of innovation have evolved through several generations, beginning with a simple, linear model. The linear model shows R&D as an input, leading through a product development phase and on to commercialisation. This is no longer seen as relevant as innovation cannot be considered a "smooth, well-behaved linear process" (Kline and Rosenberg, 1986). Instead Kline and Rosenberg proposed a "chain linked model" which sees design, rather than R&D as the driver of innovation. In their model research is conducted to support the design of innovative products as and when required, as opposed to the development of new technology leading to the design of products which utilise that technology. Since the process is complicated and unpredictable, they assert that activities should be concurrent and they emphasise the feedback loops between different stages.

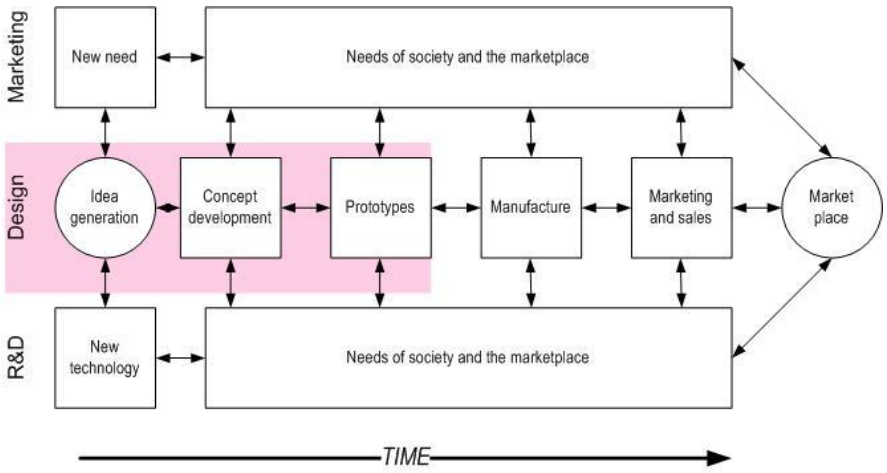


figure 4.6 – the 'Coupling Model' of Innovation, showing design as a 'bridging' function. (adapted from Rothwell (1992) by Tether (2005b).

Rothwell presented a similar model, shown in figure 4.6, in which design is a "bridge" (Tether, 2005b) between other functions which are mainly marketing, R&D and manufacturing. Design is the generator of ideas which link the needs identified in the market and technology developed through research. Although activities are arranged in a logical sequence, the authors of both models stress that this should be flexible and emphasise the interaction between different functions.

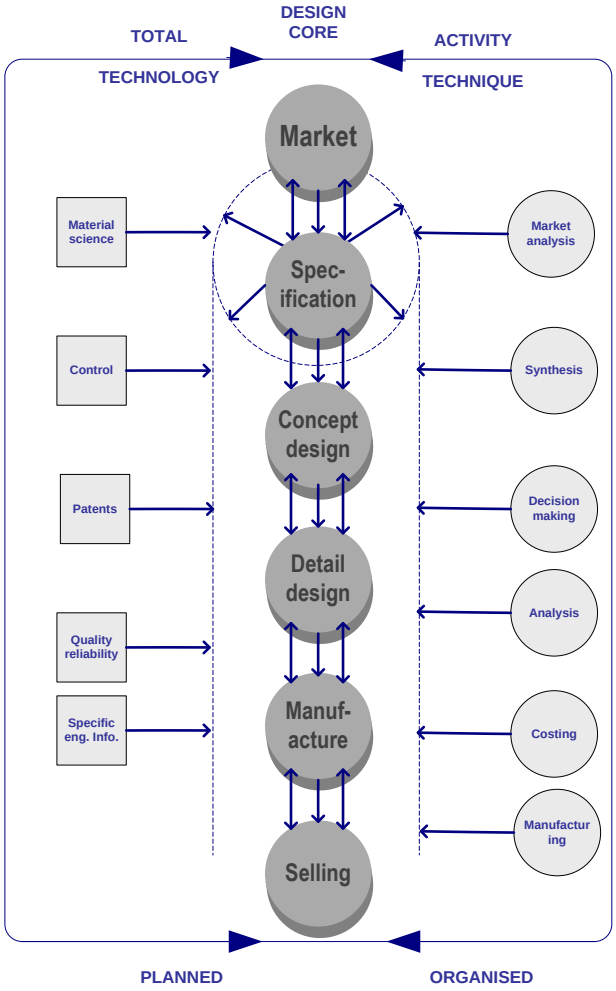


figure 4.7 – design activity cycle (diagram based on Clausing and Andrade, 1996)

A key aspect of both the chain linked and coupling models is that they view design as the central, linking function within the process of innovation. This move from linear activities following one another in a pre-determined sequence, to a simultaneous and collaborative process is referred to by names such as concurrent engineering (Pawar et al., 2002). It is also described by methodologies such as Stuart Pugh's (1991) Total Design methodology or the design activity cycle shown in figure 4.7. These approaches require consideration of the entire life cycle of a product, including manufacture, product performance, marketing, sales, maintenance and disposal. This can only be achieved by involving all functions in the process from start to finish ensuring a comprehensive view of the product. Lorenz (1986) described design as a "competitive weapon" which business managers should employ for competitiveness. He saw design as the function which connects technology and market needs to create value through products (Lorenz, 1994). Researchers have for many years considered theories based on "demand pull" or "technology push" (Dosi, 1982), design is often concerned with both, utilising technology available within the business with

the aim of meeting customers' needs. This concept is evident in figure 4.6, where design is regarded as the function which bridges the gap between R&D and marketing within the context of a business.

This can be taken as an indication that design simultaneously involves internal and external perspectives, balancing the needs of customers and the market, with the capabilities of the business or current technology. Most of these examples come from work on product design or product innovation. It has been suggested, however that innovation and design research should look at services (Tether, 2005a) and likewise, that national innovation measures should acknowledge the "hidden innovation" in services (DTI, 2007, NESTA, 2007).

4.4 Design and business performance

Over a number of years, several research groups have studied the effect that design has on business performance. Much of this work has been in the UK, but there have been significant studies in the USA and the Netherlands among others. Comparisons of different nations, industries and companies have provided significant evidence that design can be good for business. A summary of some of these studies is shown in table 4.2.

In one of the earliest studies, Black and Baker (1987) interviewed the managing directors of 61 Scottish engineering and industrial textiles firms. They studied design in the context of the product development process by defining five stages of the process and determining the firms' utilisation of design at each stage. This was used as an input measure, with growth in sales, due to the products developed, used as the output measure for the study. They discovered that 95% of the companies with a negative growth rate made no use of professional design skills. In contrast, high growth companies made significant use of industrial design throughout their new product development process.

Hart et al (1989) reported on the result of a pilot study involving 20 engineering and textiles firms. They interviewed managers on their policy towards design and opinions of what good design is. They also estimated design performance using a figure of the percentage of overall turnover created by products developed within the previous five years. The output measure of their study was a judgement on firms' 'design orientation' which allowed them to divide "pro-actors" and "re-actors". These were defined by the way they used design, to maintain an edge over competitors or to react to changes in their markets.

Walsh et al (1988) used a questionnaire to investigate over 100 hundred firms, ranging in size from under 20 to over 10,000 employees. These covered several industry sectors in the UK as well as their

competitors from Japan, Canada, Sweden, Denmark, Netherlands and West Germany. The questionnaire covered both the firm's general management (eg. organisation, strategy, future expectations) and its design management (products, processes and resources). Input measures of design included the number of awards won and measures of design performance obtained by counting the number of times peers cited their products as well designed. Quantitative output measures were used, these were financial and market performance figures including return on capital, profit growth and export sales. Another study, (Walsh et al., 1992) compared the performance of 8 'design conscious' firms with a selection of 41 non-design-conscious competing firms. They identified a generally positive relationship between design consciousness and success. Gemser and Leenders (2001) compared the business performance of matched samples from two sectors of 20 Dutch SMEs which invested 'considerably' or invested 'little or nothing' on industrial design. The conclusion was that "design innovation has significant positive performance effects in both types of industries." They found investing in design to be particularly beneficial in industries where industrial design is "relatively new" as opposed to mature.

Hertenstein and Platt (2001) acknowledged that a company's performance was affected by its industry's unique factors of production and structure. In their study of design performance they attempted to capture the "relative performance of each firm to the average for its industry." The study involved an investigation of 51 companies, from 4 industries using 12 measures of financial performance recorded over 5 years. The design input measure was a ranking of design effectiveness and quality, judged by a panel of experts from the Design Management Institute. The findings showed that in each industry, 'good' design companies performed better across all of the financial measures used. The consistency of their results over all of the measures they used were taken as confirmation of the findings, with acknowledgement of limitations in the study. The results showed the value of design for groups of companies and did not guarantee that all companies would be successful if they invested design.

> *"Effective design alone cannot overcome the effects of, for example, inefficient production or weak sales and marketing".*
>
> (Hertenstein and Platt, 2001)

Researchers	Sample	Input	Output	Method
(Black and Baker, 1987)	61 engineering and industrial textiles firms (all but 7 under 250 employees)	Use of design at five stages of product development:	Sales growth	Interviews with MD or equivalent
(Hart et al., 1989)	20 engineering(14) and textiles(6) firms employing over 100 people each	Estimated design performance - % turnover created by products developed in last 5 years	Design orientation, "pro-actors" and "re-actors"	Interviews with managers, asking about (a) policy towards design (b) opinions on what good design is
(Walsh et al., 1988)	Over 100 companies, from under 20 to over 10,000 employees in several industry sectors showing different maturity and structure. Mostly UK and some from Japan, Canada and Europe	Reputation for producing well designed products: number of awards, prizes and number of peer citations	Financial: profit margin, return on capital, asset growth, profit growth Market: turnover growth and export sales	Questionnaires with senior management and technical staff covering 1] Company management (organisation, strategy, future expectations, competitiveness) 2] Design (products, processes, resources)
(Roy and Potter, 1993)	209 companies receiving DTI/Design Council funding for design consultancy	Impact of designer on company	Profit, time until project payback	A combination of face-to-face interviews and postal questionnaires
(Sentance and Clark, 1997)	Approximately 800 firms	Design spend as a %age of turnover Design employment as %age of total	Change in profit, turnover, employment	Survey, distributed as part of a regular CBI output
(Hertenstein and Platt, 2001)	51 companies from 4 industries	Expert ranking of design effectiveness – high or low.	Financial outputs: growth in sales, net income, cash flow Returns relative to sales, assets, stock market returns	Analysis of accounts over 5 year period for publicly listed companies
(Gemser and Leenders, 2001)	20 Dutch furniture and precision instruments companies	Number of innovations, expenditure on NPD, type of innovations, use of industrial design, reasons for use/nonuse, perceived benefits of industrial design	Turnover, turnover growth, profit, profit growth, exports	Questionnaire/interviews with managers of companies investing considerably vs little or nothing in industrial design
(Borja de Mozota, 2002)	33 SMEs, European Design Award	Managers perceptions of design in their company, for example main driver for design, impact on products, skills of designers	Mean value of ratings given by survey respondents	Survey, distributed to CEO or design champion at awards ceremony

table 4.2 – a summary of previous studies on design and company performance

These studies all showed a positive correlation between design and some measures of overall business performance. They used objective measures such as profits, sales or exports as output measures but tended to use subjective input measures of design. Hertenstein and Platt, who have a strong background in accounting, discussed financial issues of design performance studies. The problem they acknowledged but were unable to solve was how to achieve a financial input measure for design. One attempt to overcome this is shown in table 4.3.

In relation to your turnover, approximately how much do you spend on bought-in services in the following categories? (please tick one box in each category

	None	<1.0%	1.0-2.9%	3.0-4.9%	5.0-9.9%	>10%
Market research						
Product development and improvement						
Appearance design						
Technical design						
Process/systems design						
Engineering design						
Graphic and brand design						

table 4.3 – a method for estimating design spending as percentage of turnover (Sentance and Clark, 1997)

Sentance and Clark (1997) used this question as part of their unique survey of around 800 firms, a sample they felt represented approximately a fifth of the UK's manufacturing industries. Their survey aimed to enable an estimation of expenditure of design at a national level. They captured spend as a percentage of turnover, where respondents were provided with a range of banded options. Design services in this study included: Market research; Product development and improvement; Appearance design; Technical design; Process/systems design; Engineering design; and Graphic and brand design. Limitations in this study include both the categorisation of 'types' of design and the choice of banded

estimates as a basis for further scaling. The first limitation is particularly pertinent, as the relationship between types is unclear, for example, technical design, process design and engineering design are not linked by a clearly articulated framework.

4.5 Research challenges

Collectively, the studies above show two major limitations, which form a gap in the research:

1. Design is difficult to define: to overcome this problem these studies focused on design in a particular context, such as product development (eg. Black and Baker, 1987) or industrial design (eg. Gemser and Leenders, 2001).
2. None of these studies accurately captured financial input measures for design, despite the use of financial outputs.

Defining design

As this chapter has already shown, the basic starting point of measurement – a definition of design - is not agreed. The usage of the word in different contexts can differ, which makes it difficult to pin down a definitive meaning. Design is often considered as an aspect of product development, often relating to product form or use. This narrow view of design fails to capture the increasingly accepted wider role of design in the firm, encompassing products, environments, identity and information (Gorb, 1990). “There are occasions when it leads to confusion and when an excessively narrow view of design hinders a broader, more strategic approach towards its management” (Schneider, 1989). Von Stamm (2004) noted that there is still confusion about the boundaries between design, design management and new product development. In industry this creates misconceptions which lead to mistrust and misuse of design skills. In research, the lack of precision makes interpreting potentially useful insights difficult. It is also problematic when attempting to capture design spending in firms. Definitional clarity is required to enable financial managers, who typically have little understanding of the subtler definitions of design, to collect data in a consistent way.

Quantifying design

The second challenge is determining what to measure and how to obtain figures. Design activities which are included in the Frascati definitions (OECD, 2002) are incorporated in R&D measures of companies. Design happens as a part of R&D, but in many organisations, there is also substantial design expenditure in other business functions (Borja de Mozota, 2002). The challenge, in measuring design is to identify what other activities should be included. Hertenstein et al (2005) also identified the problem that design

spending is immediately written off as an expense long before sales make any return possible. Retrieving the data required to calculate returns becomes difficult and something most are unwilling to do. In theory, it should be relatively straightforward to capture spending on outsourced design, but in-house design activities can prove to be more challenging. As Hertenstein et al (2005) discussed, it is difficult to separate the contribution of design from that of all other actors including engineering, manufacturing, marketing etc. Gorb and Dumas (1987) coined the phrase "silent design" to describe the design work which is conducted by non-designers in many businesses. This makes it difficult to separate design activities from all others within the business. A company may have its products designed by its engineering department, while its publicity is designed by the marketing department but neither activity is conducted by professional designers. With this in mind, most researchers have chosen to focus on narrowly defined design activities, meaning they do not capture the whole contribution of design.

Overcoming the challenges

These challenges, while frustrating, are not entirely unique. Similar issues were previously faced by those wishing to measure R&D, but have generally been overcome, with R&D now considered very much an 'accountable' (Chiesa and Frattini, 2007). A previous 'strategy of hope' (Nixon, 1998) in relation to the perceived benefits of R&D has now been replaced with a much more systematic and disciplined approach (Pearson et al., 2000). Although R&D is now well defined and consistently measured, it was once considered a creative and unstructured process (Kerssens-van-Drongelen and Cooke, 1997). This led to standard management and control techniques being considered inappropriate (Roussel et al., 1991). These issues were overcome because there was enough recognition of R&D's value to develop a means of measuring it. Design is arguably even more 'creative and unstructured' than R&D. It has been described as "the purposive application of creativity to all the activities necessary to bring ideas into use" (Bruce and Bessant, 2002). However, there is a growing recognition of the need for design spending to be better understood. This was stated in the British Standard for design management, BS7000:

> *"It is vital that the financing of design activities, particularly product design, is written into corporate, business and operating plans. The achievement of excellence in design requires funds to be allocated from clearly identified budgets well in advance."*
>
> (BSI, 1997, pg9)

4.6 Framework for categorising design activities

At present companies can identify their R&D activities and declare spending on them as an investment, while design spending is treated as an overhead. While R&D is measured according to international standards such as the Frascati manual (OECD, 1992) and accounting standards such as SSAP13 (Accounting Standards Committee, 1989) and IAS38, there is no equivalent standard for design. Whereas R&D is often concentrated in specific departments, whose spending can be identified, design is used more widely and dispersed throughout the company (Walsh, 1996). Additionally, every individual who devises a course of action and follows it (Simon, 1996) can be considered to be designing. This suggests that a good understanding of job descriptions is required, to establish how much of each individual's time is spent on useful design activity. Equally, it is important to define which design activities make a valuable contribution to the company and are therefore worth measuring. For example, selecting fonts for an internal email, may represent a design activity, but may not be considered as valuable and productive by those measuring effort on it.

For these reasons, quantifying spending on design, even with access to management accounts, would hardly be straightforward. It requires the input of the company, to help establish what should be measured and how. Therefore an exploratory approach was used to understand the types of design which occur in a variety of companies and to develop a theoretical framework which links these activities in logical categories. Essentially this framework should overcome the problem of silent design (Gorb and Dumas, 1987) and assist in classification of design activities, in a manner similar to the Frascati manual. The following sections show the logic behind the identification of categories and sub-categories of design in a framework.

Identifying categories of design

Walsh et al (1988) were among the first to study the role of design in the competitiveness of companies. They identified the impact of design on both price and non-price factors, which can be either product or company related. Design can be used to lower the cost of production or increase products' specifications and quality. Design also plays a role in the promotion of companies, delivery and servicing. Roy and Riedel (1997) expanded on this categorisation by listing a number of different roles which design can play in product competition. Design affects specifications, features, style, quality, manufacturing costs, running costs, product range extensions, product customisation and compliance with regulations. These roles

refer to design in innovation, where design overlaps with R&D in the development of products. Ulrich and Eppinger (2003) define a product as "something sold by an enterprise to its customers" (p2) a definition which does not explicitly exclude intangible or service 'products'. Indeed there is an argument that every company designs both products and services, regardless of how tangible the products they offer are (Levitt, 1981, Shostack, 1982). The offerings, or 'value propositions', which companies make and customers pay for, must be designed to meet customer needs and business objectives, regardless of whether they are more product or service.

Like R&D, design is important to businesses because it contributes to innovation in their product or service offerings. Additionally, design can have important impacts throughout an organisation (Walsh, 1996). In one study of design and competitiveness, (Lorenz, 1986) provided anecdotal evidence of design's influence in a number of successful companies. These companies utilised design to increase the competitiveness of their products, promote their brands and improve their external image as well as improving the working environment for their employees. Lorenz presented design as a competitive weapon and, in this study, showed its impact on both internal and external factors going far beyond product development.

Design is an interdisciplinary activity, which involves nearly all the functions of an organisation, particularly marketing and manufacturing functions (Ulrich and Eppinger, 2003, p3). From the literature, design could be seen to fall under three broad categories, shown in table 4.4. These are product related, customer-facing and business-facing design activities. These categories of design can be observed in many companies, although they may fall under the remit of different departments or functions in different companies. For example product development, marketing and engineering departments may carry out activities which can be seen to fall under these three categories of design.

A. 'Product' design	B. Customer facing design	C. Business facing design
Design activities related to the core offering delivered to customers, whether it is a product, service or combination.	Design activities related to communication and interaction with customers.	Design activities related to internal factors, invisible to customers.

table 4.4: three categories of design

Category A – 'Product' design

All of the products and services which customers purchase are consciously designed, whether or not they are well designed or have been created by professional designers (Walsh, 1996). Design contributes to product innovation in its capacity to reconfigure technology into products and services to be sold. Some

of this contribution is captured in R&D measures, which include design in product development. The UK Community Innovation Survey contains questions regarding the innovation activities of companies and provides useful data. It included a question relating to expenditure on design, intended to capture all those design activities which lie out-with R&D. Following analysis of the results, Tether (2006) recommended that the existing definition of R&D (basic research, applied research, experimental development) be altered. Instead he proposed categories of 'Research' - which may not be directed towards a specific application – and 'Design & Development' – systematic creative or experimental work drawing on research or experience with the objective of creating improved products or processes – should be used.

Several articles in the business press (e.g. Nussbaum, 2004, Brown, 2008) present the innovation consultancy IDEO as an example when describing how design can be used in business. The significance of this company is its emphasis on the experience of users as a starting point for designing products and services.

A traditional distinction is made between design of form and function, but the distinction can likewise be made between design which is closer to science or closer to art (Pahl and Beitz, 1996). It has been suggested (Stoneman, 2008) that some innovative activities do not necessarily produce *improved* products, but do result in innovation. For example where the aesthetics of a product are altered, the new product may be preferred by some consumers but not all, in contrast to a functional improvement. Donald Norman (2004) coined the term emotional design, in a book in which he argued that emotional as well as functional aspects of products make them successful. He argued that three aspects of products contribute to their emotional impact: behavioural (including function and ergonomics), visceral (including aesthetics and other sensory aspects) and reflective. Therefore it can be argued that design creates value by its function within technical improvement of products (or services) or in the creation of a user experience as part of products or services. This can be seen as design of function/form or engineering/industrial design in a traditional sense. However, it is also claimed that the industrial designer fulfils a wider role than the aesthetic and ergonomic aspects of products and can be viewed as the champion of user experiences, particularly those experiences related to physical products (Farr, 1966). In the 1960s (Bayazit, 2004) designers began to realise they could not focus on product form and function alone, but had to consider human needs. Subsequently, user centred methods of design have become increasingly prevalent. The distinction is perhaps clearest, in software development. While software

engineers develop and program the technical aspects of a software package, usability engineering (Nielsen, 1994) is required to design the interface between the user and the software. This includes understanding the experience of a user and designing the interface to enhance this experience.

Two sub-categories of design, which create value through their impact on the central (product or service) offering of a company can be identified:

1. Technical design: Aimed at improving technical or functional aspects of the main offering sold by a company to its customers.
2. Experiential design: Aimed at creating an emotional experience in the customer's interaction with the offering.

Category B – 'Customer-facing' design

While the first category of design activities is most visible in companies producing new products and services, design can also be seen in those which do not regularly do so. Kotler and Rath (1984) noted the role of design in optimising customer satisfaction, through its connection with products, environments, information and corporate identity. Two aspects of design which are not specifically related to product or service development (BSI, 1997) are corporate identity & culture and promotion & customer support. The former includes physical, operational and human aspects of an organisation's 'unique personality', while the latter includes advertising and promotional literature as well as showroom environments, manuals, web-sites and other outputs.

A distinction is often made between tangible products and intangible services, but it is argued that satisfying customers requires the design of both (Ramaswamy, 1996). Theodore Levitt (1981) argued that products are often sold on the basis of intangible 'promises' where the product cannot be tested but is purchased on the expectation that it will perform as promised. Conversely, services are sold with the aid of tangible 'evidence' which acts as a metaphor for tangibility. Shostack (1977) expanded this by saying that tangible products are differentiated from others by having an intangible image. For example Coca-Cola has cultivated an image of youth, while Dr Pepper's image reflects originality and risk-taking despite the two products being physically similar. In all of these instances, design is used to create a product, but also an image or brand which creates value.

Although it is the subject of debate, it has been suggested that products offer a means of communicating with customers, with design acting as the language of this communication. Crilly et al (2008) explored the communication between designers and consumers which is mediated by designed products. Verganti

(2008) similarly presented design as a driver of innovation in its capacity to alter the 'meanings' inherent in products. Clark and Fujimoto (1990a) referred to the 'product concept', an intangible idea of what a product is, which should remain consistent throughout the design and development of a product, to match customers' expectations. While this communication may occur subtly through product design, it is more noticeable in the design of advertising and communication, which creates an image in customers' minds. Verganti (2006) cited a curious example of two identical products (a kettle, with a small bird shaped whistle), created by the same designer, with one retailing for approximately a fifth of the price of the other. The more expensive model continued to sell, which he attributed to it carrying the name of Alessi, the Italian consumer manufacturer.

Oppenheimer (2005) is another writer who stressed the importance of matching customer expectations through consistency between products and the image which they hold in customers' minds. He identified a distinction between the image of the brand as a whole and individual product lines. He suggested manufacturers of digital cameras as an example, since they may have different ranges for professional and amateur users, each backed by a different promotional message. Gorb (1990) similarly made a distinction between the design of products and design of corporate identity.

The identity of a company is visibly reflected by the design of its physical (and virtual) retail environment, which has been recognised as influencing the buying decisions of customers (Kotler, 1973). This is particularly notable in service provision (Bitner, 1992), where the environment can affect customers perception of the quality of service provided. The customer experience is created through a combination of the offering sold and other factors such as the sales environment and careful identification and design of these factors can turn products and services into higher value experiences (Pine and Gilmore, 1999). Designing such experiences involves planning of specific elements of the customers' emotional journey, which have been identified by researchers (Voss and Zomerdijk, 2007). Designing the environment in which customers purchase products or receive services contributes to the image of the company as a whole.

Another two categories of design activities, which create value by supporting and promoting the company and its offerings can be derived:

1. Design as part of promotion, communication, branding, and distribution of products and services
2. Design as a part of developing, promoting, and communicating the corporate identity

Category C – 'Business-facing' design

The previous category included design activities which support the promotion and sale of products and services and are specifically aimed at customers. Another type of design, however, also supports the development of products and services and plays an important role in value creation, despite being hidden from customers. Shostack (1982) referred to the 'line of visibility' in the design of services, which distinguished those visible, front-end processes which involve customer interaction from back-office processes which are vital but invisible. It is equally the case that manufacturing involves both design of purchased products and the processes which create them. Much attention has been paid to attempts to integrate these activities (e.g. Nevins and Whitney, 1989, Pugh, 1991), but the design of systems and processes is not normally captured in studies of design.

A study of the varying roles of design in business was presented by Lorenz (1986) and is valuable in expanding the perspective beyond products alone. A recurring theme in the descriptions of successful companies was their willingness to invest in landmark buildings, for which they employed experienced designers. This is partly customer-facing in that it presents a visual image to the outside world, but also demonstrates the value of designing the workplace for its effect on employees. Vischer (2007) argued that design of offices and workplaces should not be cost-based, but instead proposed an approach to analysing the human effect. Elsbach and Bechky (2007) further analysed workplace design, highlighting the integration between human and technology requirements to optimise the effectiveness. Finally, West and Wind (2007) demonstrated that ambitious workplace design can create a flexible and functional environment. The conclusion to draw from these and other studies is that design of the workplace, rather than being an unnecessary expense, can improve productivity and effectiveness of staff. In this regard, it affects competitiveness of companies, even though its effect may be invisible to those outside of companies' workforces.

The final two categories of design activities, which create value through their effect on internal functions and environments can be added to the framework:

1. Design of systems and processes
2. Design of environments and workplaces

4.7 Case study: measuring design effort

The framework described above was used in interviews with managers, to classify their companies' design activities and allow estimates of effort on these activities to be quantified. This allowed the challenge of defining design to be partially overcome and creating a common structure to permit effort in different companies to be compared. The problem of silent design was also avoided by not focusing on the number of 'designers' but using the framework to identify activities regardless of who they are conducted by. For example, designing the user interface of a software package would be classified under the experiential, product design category. The total effort on design of user interfaces could include time spent by software engineers, graphic designers or others who may be involved.

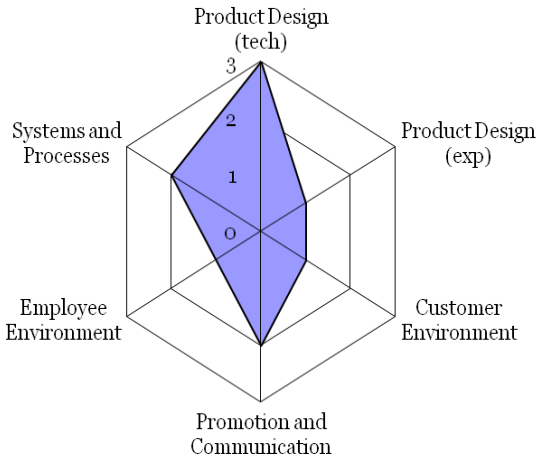
Interviews with senior managers explored their understanding and perception of what design is in their business. The interviews began with a general question about design in the context of the interviewee's company. An extensive debate about what "Design" means, outside of this context, was avoided but the question allowed an insight into role of design in the company. A questionnaire was used to capture the interviewees' estimates of spending on the design activities identified in the interview.

The research process was discussed in more detail in chapter 3, where the companies and the interview method were described. In the following summary, the six case companies will be discussed. A brief description of each company is provided, along with an overview of design activities conducted. Each description is accompanied by a chart providing a visual representation of the company's design activities. These use estimated rankings for the importance of each category of design, from 0 (not important/no effort) to 3 (very important/large proportion of design effort). It is clear that the emphasis in each firm is on different types of design. For example while one may focus almost exclusively on technical product design, another company is more reliant on experiential design, which required it to re-design its retail environment.

1. CAMCAD

The company is a developer of CAD/CAM software, which began as a University spin-off and, over three decades, has grown to become a large and successful company. CAMCAD is the largest company in the UK market, with turnover in excess of £25m and employs over 400 staff in the UK, North America, Europe and Asia. Its software is used in applications such as engineering and machining; transport

solutions; plastics & packaging and consumer products. The company also follows new opportunities including medical and dental applications.

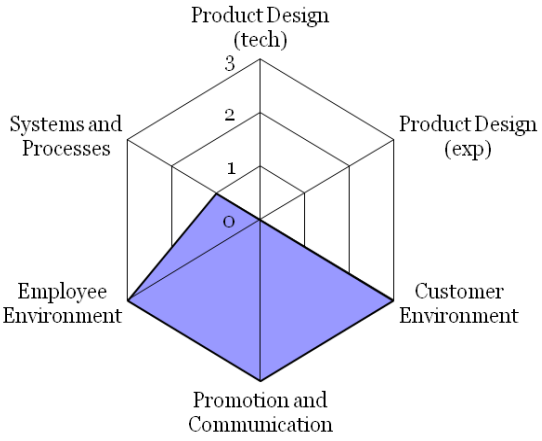


The main functions of the company are the development and sale of software, used in product design and manufacture. In recent years, there has been an increase in the services offered by the company, in addition to its software products. The standard software has been used as a platform for customised offerings to be used in specialist applications including orthopaedics and dentistry. For example, in response to a customer request a CAD package was developed to model human teeth. Additionally, the company has increased the training it offers to customers, as an added source of profit from services related to their core product.

Design activities in software development are mostly technical with a small number of full time user interface designers contributing to the 'experiential' aspects of the product. The chart shows design to be more greatly concentrated on technical design of products.

2. Tiling House

The company is a retailer of tiles for household use. It was founded in the early 1980s by two interior designers, and continues to be a small, family owned business. Recent efforts to increase profitability have seen an increase in employees and an emphasis on design.



Tiling House serves three main types of customers, the largest of whom is presently from the building trade. These customers are given a mandatory trade discount on the price of products sold, so the company is forced to compete with rivals on the basis of price. Other customer groups are interior designers or architects and consumers, who are more design conscious.

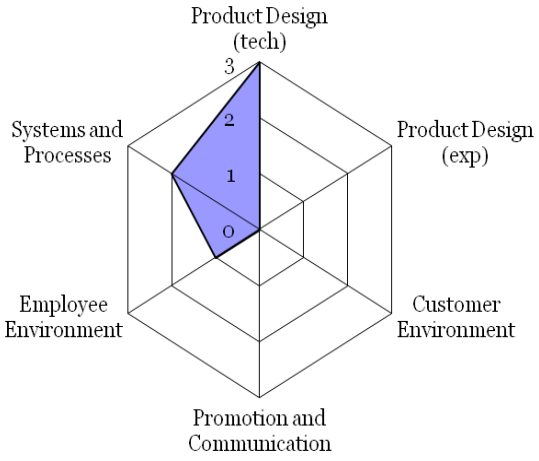
With price competition considered unsustainable, particularly when orders from the construction industry were suffering, Tiling House sought to move upmarket by targeting consumers directly. This represented a move towards offering services to end users and was enabled by the use of design in the company. Interior design graduates were recruited to the sales staff, while all staff were given design training, to increase their ability to offer customers a design service.

The most significant design spending identified was on a re-design of the retail environment, to transform the 'experience' of purchasing tiles. This is part of an intended move towards selling a high-value service and away from low price products.

3. Jones Engineering

Jones Engineering is a small manufacturing company, which offers services for bespoke design and manufacture of industrial fabrications and machines.

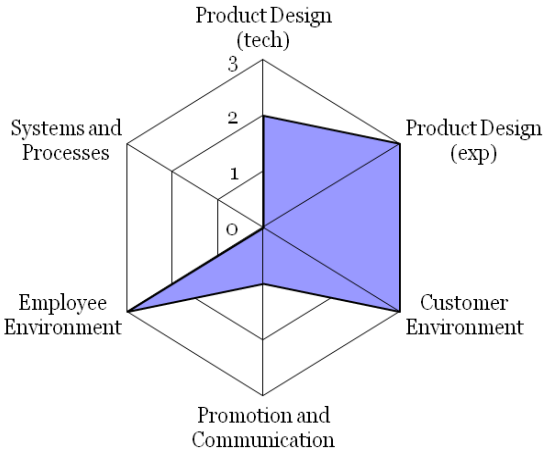
The company has a number of regular customers, who pay for specific projects, requiring varying degrees of design and fabrication. These include design and manufacture of piping and lighting, for utilities companies. Additionally, the company takes on some large construction projects, led by the technical director with input from engineering designers. Previous projects have included the design of a complex rotating structure as part of an award winning building. Such projects help to bring orders through word of mouth, but are not actively used to promote the company's design capability, with the technical director expressing a fear of being seen as a design company. Instead, the company seeks to maintain consistent orders from utilities companies, to ensure the manufacturing personnel have a constant supply of work.



Design spending is almost exclusively on technical aspects of products and components.

4. Perfect Peach

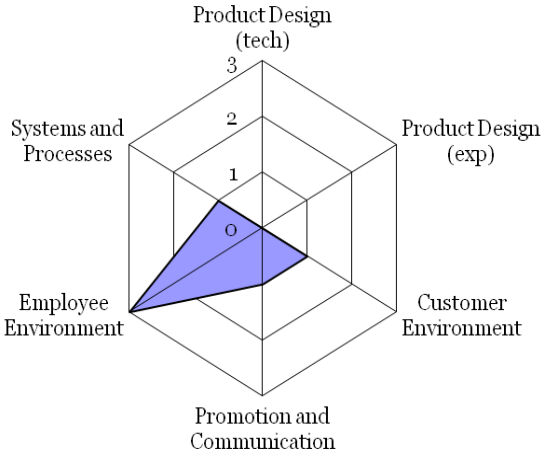
Perfect Peach is a small but successful web design company which has sustained rapid growth and expansion into other multimedia services. As part of its expansion, the company has recently moved into new premises, which were specifically designed to create a productive working environment and facility to accommodate meetings with customers. This has contributed to a good record for staff retention and increases the desirability of the company for prospective employees. When meeting potential customers, the result is that meetings held in the company's offices invariably result in sales. Customers are met by sales people who agree specifications and contracts, while designers and developers, referred to as "creatives" or "geeks", are shielded from any direct communication with customers. Perfect Peach conveys an image, through subtle and careful use of design, intended to assure customers of their professional credentials. This is evident from the branding and logo to the stationery on which communications with customers are printed.



As a web-design company, the design of products, from both a technical and experiential perspective is important. A significant recent design cost was in commissioning the design of the company's new office, incorporating both customer and employee areas.

5. Expert Info (facilities management)

Expert Info is a large, multinational company which develops IT based solutions and provides its clients with business information and analysis services. The interview was with the head of the facilities management department, responsible for maintaining the company's buildings and for overseeing construction of new ones where required.



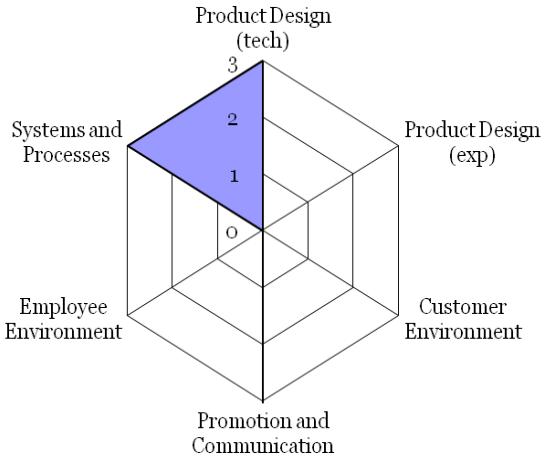
Of the total activity of the facilities management team, an estimated 60% could be classed as design activity. This mainly involves managing available space to ensure that employees are provided with all required equipment and facilities. The rooms are designed to ensure optimum utilisation of available space, create a flexible working environment for staff and to ensure technical requirements, such as the need for telephone lines and wireless internet access, are met. A particularly significant design cost came in the construction of a new building, which received some media coverage for its striking design. The emphasis in the design was to create an environment which increases staff productivity, for example through the use of glass to provide natural light. The building also serves as an advert to the outside world, due to its location on one of the main routes into the city. In this function, care was taken to avoid an image of "opulence", but the building is intended to give a good impression.

The main function of the facilities management group (although not the organisation as a whole) is to design the employee environment. Design is used to improve efficiency and productivity of the workforce, but this can also serve the function of promoting the business to potential customers and employees.

6. Aeroservices

Aeroservices is a producer of complex products for aerospace and defence applications. Its main customer is the Ministry of Defence (MoD), for which it designs, produces and supports a variety of products. While in the past, the product and its associated service were purchased separately by customers, the MoD now offers combined contracts. This means what is purchased is not a product, but the capability which that product provides. For example, contracts might specify the capability to train pilots. Such a contract would require provision of aircraft and/or flight simulators, which should be fuelled and functioning as and when required.

Products are partially designed in anticipation of future requirements, in order that bids can be made to win contracts in a small, but highly competitive and lucrative market. This design is highly technical but surprisingly low in radical innovation, since safety and reliability are major concerns.



The company designs highly complex products, requiring collaboration with suppliers and partners. The new contracts, however, mean that product design is a small part of the work required. The interviewee

suggested that the largest design costs are for the systems which support these products, involving networks of collaborating companies.

Discussion

The simplest way to measure firms' spending would be to ask the question "how much do you spend on design?" Remarkably, some companies – particularly those which did not agree to interviews - responded by saying "we don't do design" or at least did not keep a specific account of design spending. 'Silent design' (Gorb and Dumas, 1987) means that design is not always recognised as such by those who conduct it. To avoid this problem, the approach taken was to classify specific activities that would be considered to be design activities. As shown above, Sentance and Clark (1997) had some success with this approach. They focused on product development activities which are normally conducted by within a firm, by dedicated staff.

In all of the case companies, design can be identified in some form and the interviewees were able to provide some estimated figures for design spending. This was despite the belief of some interviewees that their companies "don't do" design. It is likely that every company undertakes some design, whether in-house or out-sourced, by dedicated designers or by other staff. Unlike other activities, for example R&D, the amount spent on design is not always measured to a suitable degree of accuracy. It may, however, be beneficial for the companies' financial managers to have a means of measuring design spending. Equally, strategic management would benefit from a comparison of this figure with the design spending of rival companies. For operations managers, the measurement of design effort is an incredibly valuable tool for managing existing projects and planning resources required for future projects.

In previous studies, an implicit aim has been to prove the value of design or to encourage companies to spend money on design. However, in the present study, it is evident that spending on different types of design may be more appropriate in certain circumstances. In some of the companies, design of products is most important, while in others, for example Tiling House, standard products are not designed by the company, but design is applied to the environment. Equally, experiential aspects of products may be more important in some products than the technical aspects which may not be regularly re-designed. An understanding of what types of design are most appropriate for a company's strategy would allow managers to determine where resources should be allocated.

An unexpected but intriguing finding was the increased emphasis on services in several of the case companies. An observation made in several of the case companies was that design was closely linked to

an increase in service activities. Each one of these companies can be seen to have made or be currently making a product-service transition. In Aeroservices, this was particularly clear, since the business model they operate on had dramatically changed due to customer demands. The design and development of their products is still a major focus, but technology alone does not win contracts, rather the ability to deliver a service, which guarantees the availability of this technology is a selling point. To a lesser extent, some of the other companies appeared to be increasing their services, to compete in saturated markets or to target higher value customers. Their use of design contributes to the transitions they make, for example by enhancing the customer experience or by enabling the customisation of standard products as a service. As indicated in the charts above, the role of design differs by industry sector and other variables. They also suggest that the role of design changes in companies making a product-service transition, a topic which offered opportunities for further study.

Conclusion

This study sought to develop a method for studying design which allows comparison between different companies. a framework was developed from a review of literature and validated through a case study involving interviews at six different companies. The interviews focused on classifying design activities and seeking estimates of spending on these activities, as an indication of the importance of these types of design and the effort devoted to them. This study contributed to the development of a survey instrument, which was later used in a national survey of design spending, by colleagues at the University of Cambridge (Livesey and Moultrie, 2008). It also raised the issue of product-service transitions and the contribution of design to them, which became the main topic of this research.

When visiting the companies in the study, the researcher was struck by a sense that services were increasing in their importance to these companies. Having a background in product design, service design was a relatively new topic. It was interesting to observe that the manufacturing companies included in this study relied heavily on services. For examples, Jones Engineering is described as an engineering services company, despite designing and manufacturing products. Meanwhile AeroServices was considered to be a manufacturer of complex products, but in fact earns most of its revenue from services delivered through its products. And Tiling House was one of the most intriguing of the companies, since its increasing focus on higher value service offerings was clearly facilitated by its attempts to develop its design capability. This led to a desire to learn more about services and, particularly, how widespread the use of design to transition to services might be.

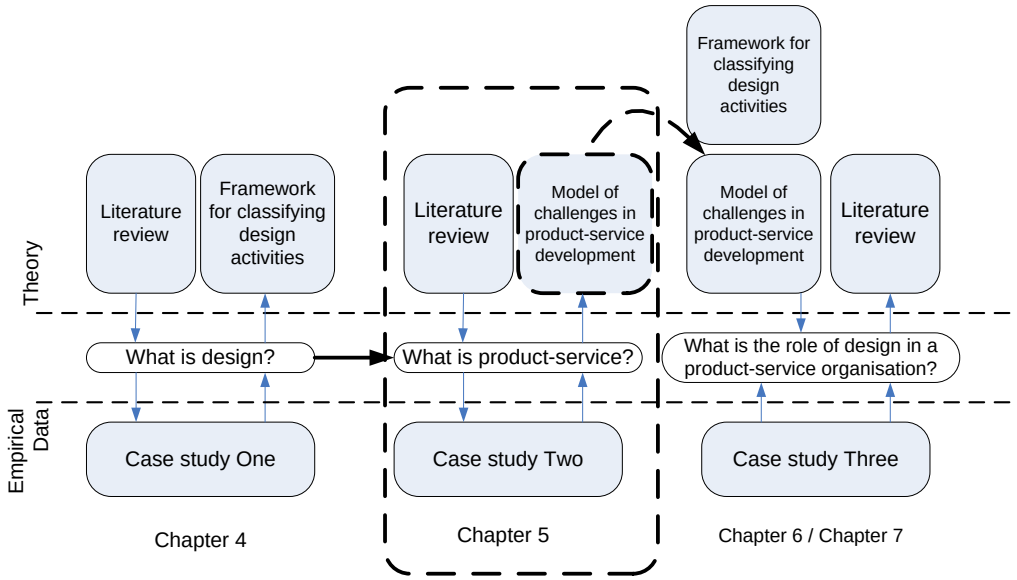
Chapter 5
Product-Service Organisations

> *"…there are no such thing as service industries, there are only industries whose service components are greater or less than those of other industries. Everyone is in service"*
>
> (Levitt, 1972)

This chapter is concerned with the transition to product-service business. It begins with a review of the literature to clarify the nature of product-service systems and the transition towards them, from traditional product manufacturing. Firstly, the question "what is service?" is posed. Then the nature of a 'product-service' is explored to attempt a working definition. Proceeding to the question of how to design and deliver such product-services, the literature is reviewed to develop a framework which addresses the design of the product, service and the organisation which creates and delivers them. Finally, case studies are presented which allow the framework to be developed further by identifying challenges for companies to overcome and for the writer to investigate further.

Relevant Publications

1. Pawar, **Beltagui,** Riedel (2009) "PSO triangle: designing product, service and organisation to create value", International Journal of Operations and Production Management, Vol.29, No.5, pp.468-493.
2. **Beltagui**, Pawar, Riedel (2009) The role of design in the provision of solutions and experiences, 15th International Conference on Concurrent Enterprising (ICE 2008), Leiden, Netherlands, 22 - 24 June.
3. **Beltagui**, Riedel, Pawar (2008) Product-Service business – research questions, 14th International Conference on Concurrent Enterprising (ICE 2008), Lisbon, Portugal, 23 - 25 June.



This chapter explores product-service organisations. The previous chapter investigated the role of design in businesses and found that companies can use design as part of a product-service transition. A review of literature on the topic identified that others had noted the phenomenon of 'servitization' and that manufacturing, services and the transition between them are present topics of considerable interest among researchers. The chapter presents a literature review of understandings of service and product-service, before considering the design of product-service offerings and developing a model to highlight the challenges and considerations in designing these offerings. Two cases are presented which explore specific aspects of this model and help to complete the picture presented.

5.1 What is service?

It has been claimed (Chase and Apte, 2007) that Adam Smith was the first to refer to what is now the service sector when discussing "non-productive economic activities". Historically, primary (agriculture and mining) or secondary (manufacturing and industrial) activities were considered valuable, while services were classed as tertiary or 'other' activities. Today there has been a major turn around to the extent where the value of manufacturing is now questioned.

> *"…does manufacturing have a future in the twenty-first century or are we becoming a service economy?"*
>
> (Davies, 2003)

Evolution of service research

Fisk et al. (1993) traced the history of service management research, identifying a number of stages in the 'evolution' of the literature. In the earliest stage, the focus was on justifying the value of studying services by arguing that they are "different" to manufacturing goods. Service researchers tried to "break

free" from product marketing and management (Shostack, 1977). The initial aim, in the 'crawling out' stage, was to establish the unique characteristics of services, which were subsequently reinforced in the highly active 'scurrying about' stage. Building upon this, the walking erect stage represents the recognition of services research as valid in their own right. Service management research is largely fragmented across a number of different areas, most notably marketing and operations management. Arguments have repeatedly emerged that integration between the two is essential, notably in a special issue of Journal of Operations Management (Berry et al., 1991), an argument repeated in a later special issue (Malhotra and Sharma, 2002). Johnston (1999) however, argued that the field of service management has become significantly broad to justify a return to the roots of each discipline concerned. He is among those who argue that studying services from an operations management perspective offers an important and under utilised opportunity to contribute to knowledge.

Service Operations

Leffingwell's application of Frederick Taylor's (1911) scientific management to service firms such as banks is considered one of the first cases of service operations management (Chase and Apte, 2007). Over the years services have become more important and have been addressed to a greater degree in operations management, but perhaps not enough attention is paid. Slack et al (2004) charted the development of the operations management field from its origins as "factory management". They examined publications in two international journals, noting the bias towards manufacturing in the numbers of papers published. They accepted that researchers should focus on the topics they see as important but highlighted a gap between research and practice.

As Slack et al (2004) showed, operations management still reflects its origins in its bias towards manufacturing, which is at odds with the increasing dominance of services in practice. Robert Johnston (1994) argued vehemently that operations management should move beyond efficiency oriented analytical work aimed at improving manufacturing systems or face becoming irrelevant. He challenged service management researchers to focus on operations issues and operations management researchers to "bring the service imperative into the mainstream discipline". This requires them to be more customer and service focused, something which he did not feel was possible for all. Conversely, Theodore Levitt (1972) considered service industries to be "primitive and inefficient" in comparison with manufacturing. He argued that service firms should learn from manufacturers by improving the efficiency of their processes and asking questions such as "how can things be designed to work more efficiently". As

services have grown in importance, it has been increasingly recognised that all firms combine the two. Armistead (1987) suggested representing a firm's level of manufacture, service, supply and transport could be used to position it on an "operations tetrahedron." He recognised, however that manufacture and service are "theoretical pure states" and that every business and industry fits somewhere in between.

Robert Johnston (1994) considered OM scholars' interest in service to be "relatively new". This was surprising since he regarded service operations to be "at least as old as production activities", despite the emphasis of most researchers. He argued that the most pressing concerns for OM had become issues such as delivery time and service quality. While previously OM researchers had sought the decoupling point in service systems where their focus could be on technical, back-office efficiency (Chase, 1981), a focus on customers, particularly at a behavioural or emotional level (Chase and Dasu, 2001) are now important concerns. Roth and Menor (2003) described New Service Development as a 'newer topic' in Service Operations Management and one which requires a great deal of investigation by researchers. They recommended the use of studies which evaluated capabilities and service operations management strategy dynamically. They also stressed the importance of considering customers in service operations management.

Characteristics of services

Philip Kotler described services as

> *"any activity or benefit that one party can give to another that is essentially intangible and does not result in the ownership of anything. Its production may or may not be tied to a physical product."*
>
> (Kotler, 2003)

Zeithaml et al (1985) identified the four characteristics of services which recurred most often in the literature. Although these are now questioned by researchers, these four characteristics can still be found in service textbooks in both marketing and operations management (eg. Kotler, 2003, Fitzsimmons and Fitzsimmons, 2006):

- **Intangibility:** services cannot be seen or touched before purchase so they must be sold on the basis of some tangible 'evidence'.
- Variability (**Heterogeneity**): services depend upon the people who deliver them, meaning they cannot be standardised in the same way as mass produced goods.
- **Inseparability**: production and delivery of services happen simultaneously so the customer must be involved and cannot be separated from the processes which create the service.

- **Perishability**: services cannot be stored in a warehouse until needed, making fluctuations in demand harder to manage than for physical goods.

These characteristics were referred to as 'IHIP' by Edvardsson et al (2005) and Aurajo and Spring (2006) who argued they are no longer sufficient to define services. Vargo and Lusch (2004b) referred to them as "myths" while Correa et al (2007) argued that a different classification could be more useful for managing operations. These characteristics are no longer seen as exclusive to services and may have outlived their use. Consequently there is a need for research which examines the relationship between manufacturing and services and incorporates both operations and marketing perspectives on service management (Cook et al., 1999, Wright and Mechling, 2002, Grove et al., 2003).

Everyone is in service

Some have preferred to avoid using the IHIP characteristics but separated products and services by their degree of tangibility. This distinction is used to demonstrate a continuum of goods and services, such as those below.

figure 5.1– a continuum of product content in services (BS7000-3, 1994)

The diagram in figure 5.1 demonstrates that a variety exists in the 'product content' of various services. The different categories of services are distinguished by their use of tangible products. At one extreme, the customer buys a physical product – a vehicle in this case – and is offered a service package which may include customisation and maintenance among others. At the other end of the continuum are legal services where the customer is offered nothing physical other than documents printed on paper perhaps. They pay not for the documents but for the process which creates them and for the skills and expertise of those who conduct it.

In figure 5.2, it can be seen that a product – service continuum has many different levels, rather than a binary separation of goods and services. The continuum ranges from "service dominant entities" such as teaching, which do not require any tangible product offering, to the "product dominant entities" exemplified by salt, a basic commodity which requires no intangible service elements. Crucially, this

diagram demonstrates the notion that everything which is sold contains combinations of product and service elements and they are distinguished by the degree of tangibility in the overall offering.

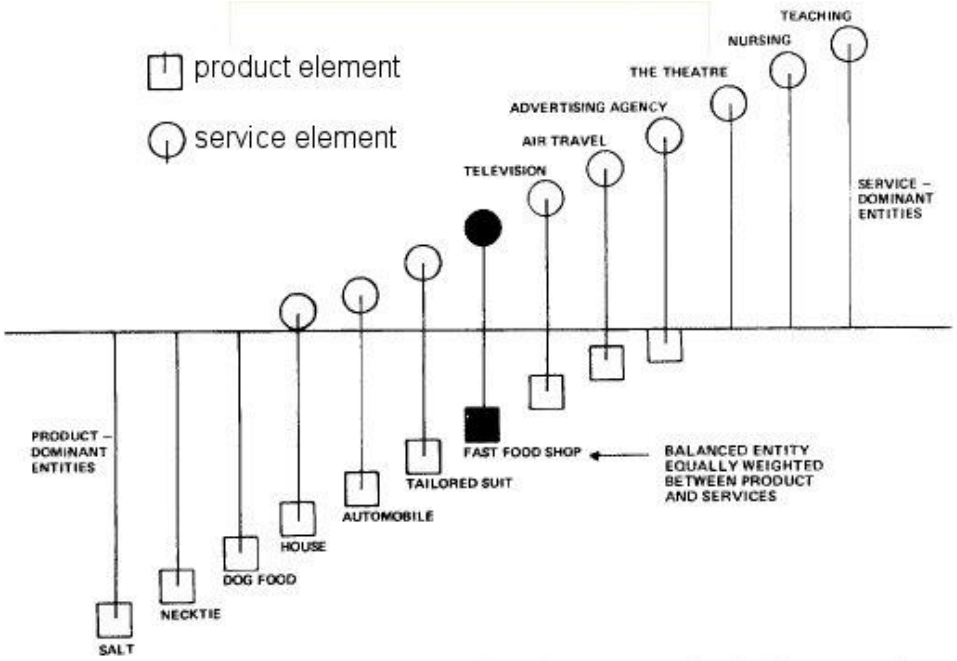


figure 5.2 – another continuum showing dominance of product or service in various industries (Shostack, 1982, Donaldson et al., 2006)

Tangibility

As demonstrated in figure 5.2, it has been suggested that every industry, whether it is regarded as manufacturing or service offers a service to its customers. Theodore Levitt (1981) avoided the product/service distinction but distinguished between tangibles and intangibles according to whether they can be assessed and tested prior to their use. While intangibles are impossible to test in advance, complex products may produce different results depending on usage conditions. In both cases, "you won't know how it performs until it's put to work". This means that tangibles need to be 'intangibilised' as much as intangibles need to be "tangibilised — or to create metaphors or surrogates for tangibility". He claimed that even tangible goods are sold on the basis of "promises" which are essentially intangible. This is because a product may not perform as intended if it is not used or installed in a certain way so the customer will not get exactly what is 'promised'.

Shostack (1977) expanded this by saying that tangible products are differentiated from others by having an intangible image. For example Coca-Cola "is surrounded with visual, verbal and aural associations with authenticity and youth". Dr Pepper, on the other hand, has an image which reflects "originality and risk-taking" despite the two products being almost identical. In the case of intangible services however,

customers make buying decisions on the basis of the "tangible evidence" offered. In this way it is argued that a combination of tangible and intangible elements is required and should be utilised by all manufacturing and service firms. Satisfying customers requires

> *"the creative blending of two fundamentally dissimilar components. It requires the integration of the generic with the individual, the expected with the spontaneous, the tangible with the intangible."*
>
> (Ramaswamy, 1996, pg15)

Service Design

As described in chapter 4, design can mean many things, but in this research it is taken to be the process of conceptualising and planning a product or service prior to its production or implementation. To carry out this process properly, it is necessary to consider all relevant criteria which will affect the success of what is produced and delivered. Pugh (1991) presented a description of such a process, titled "Total Design" because of its attempt to include the total life-cycle of a product in the design process. This is an engineering, product design approach but is relevant to the design of services because it requires designers to take a life-cycle view of product development. Total design requires consideration of service aspects like delivery, maintenance and disposal early in the process and quantifies customer requirements as performance measures. Hollins and Hollins (1991) and Ramaswamy (1996) both published books describing how to design services and maintain customer relationships for life, which were based on the Total Design methodology. While these publications offer valuable advice on how to design services, they offer adaptations of a product design methodology or even recommendations on how to apply total design to service.

The design process is taught to students of engineering, architecture, business and other disciplines, but the focus has normally been on the design and development of products. Academic courses devoted to the design of services are a new addition to universities in the UK (Bushell, 2007). Hollins and Hollins (1991) considered teaching of design to be too focused on product design, in contrast to the increasing interest of their students in services. They argued that service sectors had not grasped the value of design and its potential contribution to their success in the way that some manufacturers had over time.

Shostack (1982) was one of the first to address service design, through the use of techniques such as service blue-printing and identifying concepts such as the "line of visibility" in a business (Shostack, 1984). She introduced the method of 'molecular modelling' to incorporate the tangible and intangible aspects of a combined offering as 'atoms' within a molecule. This allows a visual representation of service elements and helps to identify all of the components of a complex entity. Crucially, it

demonstrates the effect that re-arranging the constituent parts will have on the whole, as shown in figure 5.3.

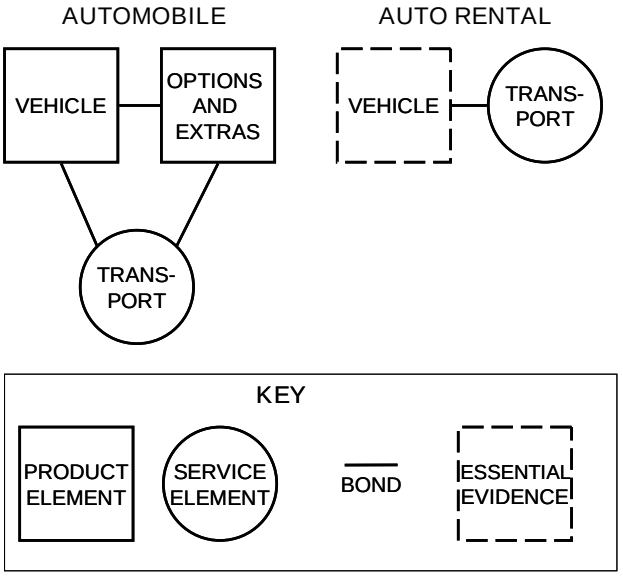


figure 5.33 – 'Molecular Modelling' shows the effect of altering product and service elements (adapted from Shostack, 1982)

More recent research follows Shostack's understanding that tangible and intangible elements are required, emphasising how the combinations create value for customers (Morelli, 2006, Tan et al., 2008). Vandermerwe (2000) introduced the Customer Activity Cycle, which can be used as the basis for designing a new service. The aim is to identify what benefits the product purchased by a customer provide and understand ways value could be added pre-purchase and post-purchase. An important point to note is that value is not seen as a quality embedded into the product at the production stage. Instead it is considered to be created through the customer's interaction with a product. That is, the value in use of a purchased product.

5.2 Value in use

> *"The word value, it is to be observed, has two different meanings, and sometimes expresses the utility of some particular object, and sometimes the power of purchasing other goods which the possession of that object conveys. The one may be called 'value in use'; the other, 'value in exchange'."*
>
> (Smith, 1776)

Adam Smith (1776) differentiated the value of a product's utility from its monetary value. Similarly, it is possible to distinguish between value from a producer and customer's perspective, which are not necessarily equivalent. Walters and Rainbird (2007) described the need to see value as created through marketing and service processes, rather than maximised in production. This 'value led' management

means it is less important for all resources and assets to focus on collaboration and co-operation to manage them. The result is an organisation which is proactive rather than market responsive and emphasises customer related performance measures as opposed to being cost-led.

The design processes described in chapter 4 (e.g. Pugh, 1991) begin with the identification of market needs, followed by specification of a product's requirements. Techniques such as quality function deployment (Akao, 1991) are used to transform the 'voice of the customer' into technical requirements and quantified specifications, feeding directly into the design process. Woodruff (1997) noted that few companies measure customer satisfaction effectively and even fewer effectively act on the voice of these customers. Additionally, there is an implication that customers speak with a single 'voice' when in fact there may be many customers all with different concepts of value. In offering a service, there is an opportunity to customise the offering to specific customers, but recognition that voice of customer is insufficient raises the issue of how to define the value which customers seek.

Various researchers have examined how to design product-service systems, breaking products into two aspects: their function and how they affect users (Tan et al., 2008). Design of product-service combinations begins with identifying customers' value expectations and this involves understanding their use of products. Methods have been proposed such as customer value chain analysis (Donaldson et al., 2006) and the customer activity cycle (Vandermerwe, 2000) as methods of capturing value.

Value co-creation

In the marketing literature, it is proposed that value should no longer be viewed as added through production processes, but 'co-created' with customers. This is represented in figure 5.4, which indicates the interaction between consumers and producers is less one sided. How to achieve this co-creation is often unclear.

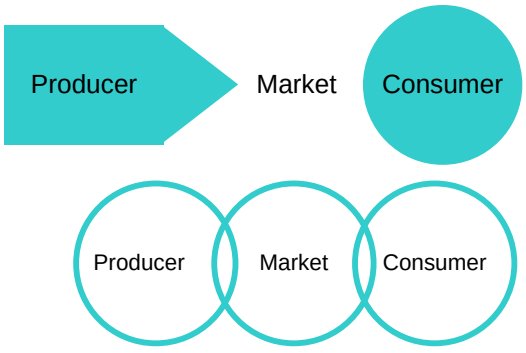


figure 5.4 – value may be embedded in produts pushed out to consumers or 'co-created' with customers (Prahalad and Ramaswamy, 2004a)

Prahalad and Ramaswamy (2004b) explored the concept of co-creation, arguing that even where companies appear to give customers options, they are not truly engaging in co-creation because they are firm-centric, offering only options which are convenient to the firm, rather than whatever the customer can imagine. The focus on customers, while potentially useful, creates the danger that internal factors will be

ignored. For example, in arguing that automobile manufacturers are firm centric in offering customers a range of options to customise their cars, Prahalad and Ramaswamy do not acknowledge the feasibility of providing other options. Von Hippel (2006) provided examples of user led innovations, whereby users developed new features which were then refined and produced more cheaply and effectively by the manufacturers. A feature of Von Hippel's research is the identification of different roles and specialisations for the firm and the user. In general, the co-creation literature fails to explicitly recognise these different roles and, by focusing on value, often overlooks the physical requirements of producing the products or services which can be used to (co-)create this value.

Vargo and Lusch (2004a) stimulated intense debate with their argument that a "new dominant logic" is required which moves away from an emphasis on manufacturing and selling tangible products. Through a detailed review of literature, they showed the need for research which would view services and manufactured goods as part of a whole package. They also argued that the managerial implication would be for marketing to become central to all businesses. Conversely, Grönroos (2000) insisted all employees within a company should become more customer focused, rather than just the marketing personnel. He made an important point when stating that choosing one strategic approach does not mean rejecting all aspects of other approaches. Even if a service perspective is the main strategy, the "core product platform" still needs to be developed and produced in a cost effective way.

> *"They don't want less products but they do want the services that assist them make the right decisions, get the product when and where they want it, utilize what they've bought to its full potential and cope when things go wrong."*
>
> (Vandermerwe and Rada, 1988)

Ownership to access

In seeking to understand services, Spring and Araujo (2009) and Sampson (2007) have reviewed definitions and their credibility over time. Both reject intangibility as a distinguishing feature of services, since it does not describe all services and is not unique to services. For example, surgery could hardly be described as intangible to the patient concerned, while software is often developed and sold as a product. Sampson lists a number of different paradigms used to define services, arguing that those emanating from the field of marketing are unsuccessful in distinguishing products and services, while the two he identifies from the field of operations management are argued to be more useful. These are the customer contact theory (Chase, 1980) and his own unified services theory (Sampson and Froehle, 2006) – modestly named after Einstein's unified field theory of magnetism and gravity. He also presents evidence

that students are more likely to favour his approach than the marketing definitions, based on a survey (Sampson, 2007).

The unified services theory states that a service is a process in which the customer provides a significant input into the production. It argues that customers contribute information, belongings or their own person, thereby acting as suppliers as well as customers. This differs from manufacturing, in which the customer may provide information or other input at the design stage, but does not have any interaction during production. Spring and Araujo (2009) argue that this theory views customers as merely the users of value which is created by producers, as opposed to being co-creators of value as marketing researchers would view them. They preferred the rental/access paradigm, which emerged from the arguments of several 20th century economists and their considerations of the nature of value. This is the only one of the theories they considered which fully explained not only how services differ from products, but how product-service offerings can be understood. This also focuses on the fact that a service operates on something belonging to the customer, but is less focused on the production process, but rather the ownership of the belongings operated on.

> *"…if a worker on a car assembly line fits a tyre to a wheel, it is considered to be a manufacturing operation, because what results is a "thing" – a completed car. If a garage worker fits a new tyre to a car brought in by its owner, it is considered to be a service operation."*
>
> (Spring and Araujo, 2009, p449)

The implication is that if the object being operated on belongs to the customer, then the operation is considered a service, whereas if the object is owned by the company, the same operation is considered to be manufacturing.

Competencies

Mintzberg et al (1998) gave examples of how 'marketing myopia' (Levitt, 1960) could be misinterpreted. Levitt attempted to free businesses of the restrictions placed by limiting themselves to only one industry, by defining themselves in terms of customer needs. It is important, however, that the competences of the business be considered and that the business defines itself in more than "a few clever words on a piece of paper." For example, a car maker can define itself as a provider of transportation, but cannot over night provide its customers with air travel, and would perhaps be unwise to ignore the advantage it has in terms of specialised manufacturing facilities for making cars. Another example is the suggestion that buggy whip manufacturers could have survived had they defined their business as 'making self-starters for carriages'.

> *"But what in the world would have made them capable of doing that? These products shared nothing in common – no material supply, no technology, no production process, no distribution channel – save a thought in somebody's head about making vehicles move."*
>
> (Mintzberg et al., 1998)

The 'service factory' (Chase and Garvin, 1989) was a proposal for how manufacturing companies could offer service. It was suggested that staff on a production line should be contacted directly by customers since they possess superior knowledge of products to dedicated sales or marketing staff. There is an added benefit of service in that it allows a deeper understanding of customers which can in turn be used to improve the design of products. Porter (1996) commented that manufacturers often focus on cost and efficiency, chasing short term profits at the expense of the strategic advantage they can gain from understanding customers' value expectations. Slywotzky and Morrison (1997) suggested that value "implies stakeholder satisfaction, which is a broader consideration than simply that of customers' expectations." This involves satisfying the requirements of employees, suppliers, shareholders and others, each of whom has a different definition of value. Normann and Ramirez (1994) argued that strategy should not be focused on a particular organisation but the value creating system, within which a series of partnerships or alliances work together to 'co-produce' value. The essence of this argument is that many different stakeholders are involved in jointly producing value, and overall performance must be optimised. This is in contrast to a traditional supply chain, in which each organisation is a separate entity, maximising its own goals, but performance is 'sub-optimised' (Bititci et al., 2005).

Normann and Ramirez (1994) argued against a purely internal focus on core competencies, followed by consideration of links to customers. An alternative is a customer centred approach, whereby customer value is seen as the first link in the chain, with everything else following. This can also be linked to an argument that every organisation should be focused on the needs of the ultimate customer or end user.

> *"So, for example, a component supplier must understand the economic motivations of the manufacturer who buys the components, the distributor who takes the manufacturer's products to sell and the end-user consumer"*
>
> (Slywotzky and Morrison, 1997)

5.3 Servitization

> *"Servitization is happening in almost all industries on a global scale. Swept up by the forces of deregulation, technology, globalization and fierce competitive pressure, both service companies and manufacturers are moving more dramatically into services."*
>
> (Vandermerwe and Rada, 1988)

The term servitization emerged from a study of senior managers in a selection of service and manufacturing organisations. It revealed that, despite traditional classifications and the best efforts of

academics to separate manufacturing and service, the lines were not always clear. Vandermerwe and Rada (1988) identified a holistic approach by managers towards their businesses and customers. This was largely due to "managers looking at their customers' needs as a whole, moving from the old and outdated focus on goods or services to integrated "bundles" or systems" (pg 314). The new approach was termed servitization, and was defined as the trend towards bundles of customer focused combinations, dominated by service (pg 314).

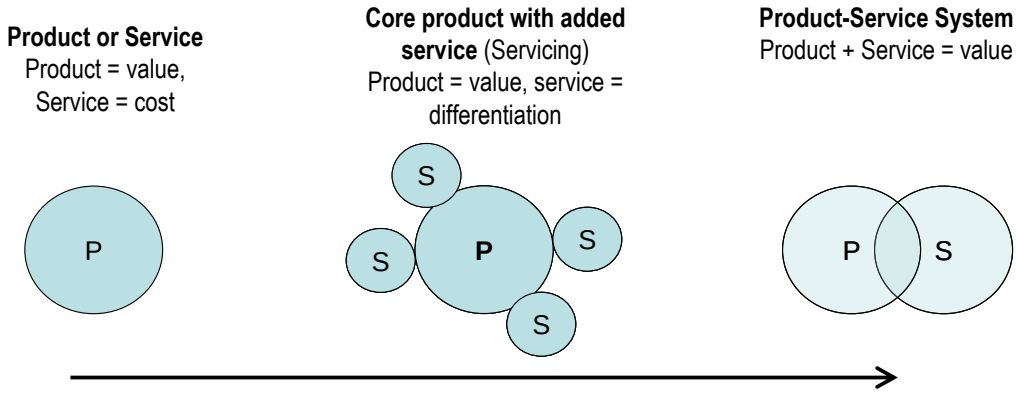


figure 5.5 – the servitization of manufacturing (based on Vandermerwe and Rada, 1988)

Servitization refers to **"the trend towards bundles of customer focused combinations, dominated by service"**. This trend was described in three stages of development, shown in figure 5.5, these are:

1. Goods or services: Companies fit in one or the other and are comfortable to describe themselves as such.
2. Goods + services: Manufacturers, particularly computer companies, found services necessary, indeed 'inseparable'. Service companies, like banks, began using more products and taking more control over the design of these products.
3. Goods + services + support + knowledge + self service: firms offer "bundles" of customer focused combinations, including all of these [goods seem to be central but] "services dominate in this era".

Traditionally, services may have been "considered as a harmful necessity" (Mathieu, 2001) by manufacturing firms. Services were restricted to a minor role such as after-sales support, but have gradually gained importance. They are now considered by manufacturing firms to be a source of added value, rather than a cost. The emphasis has shifted to the extent that some "now view the manufactured products as incidental" (Ward and Graves, 2007). What is sold is often not the product itself but the benefit which a customer extracts from its use in other words, the value of a product and its associated

services. High quality, high performance, state-of-the-art goods are simply the minimum criterion for customers to make a purchase (Hill, 2000). While they do not want less products, they do expect more services to be included in the overall package (Vandermerwe and Rada, 1988).

Product-service offerings

According to Grönroos (2000), the "core solution" of a company, whether it be a product or service, must be supported by the right "service offering" to generate any competitive advantage. He highlighted the importance of relationships with customers and stated that all organisations should consider themselves to be providing their customers with a service. Additionally, customers should not be seen as buying goods or services, but buying the associated benefits which these things provide. The failure to do so has been described as "marketing myopia" (Levitt, 1960) – failing to understand the benefits customers seek by restricting 'vision' to the medium through which they obtain these benefits. An example would be an automotive manufacturer regarding other types of cars as their only competition. The argument is that they should consider themselves to be selling transportation – competing against trains, buses and even aeroplanes – not just other car companies. Shostack's (1982), approach allows two different forms of transportation to be compared, for example an airline with a car maker. The former sells the destination to their customers, with a seat on an aeroplane used to reach it but no ownership offered. The latter sells the ability to transport one-self, including the benefits of ownership. Ultimately, the whole package must be examined where in the past the focus may have been on simply improving performance of the physical product. This means treating goods and services as part of a whole rather than separating them.

What is sold is not the product itself but the function which the customer uses it for, in other words the value extracted from the product and its associated services. This concept is not entirely new: Xerox sold a service including lease and maintenance of copiers more than thirty years ago because customers couldn't afford to buy them. Today, adopting such an approach to service is not done merely for price benefit, it is a

> *"…a more sophisticated way of blending manufacturing with service provision involves selling, not the manufactured good itself with accompanying services, but the underlying thing that the customer actually wants"*
>
> (CRIC, 2006).

Examples of product-service offerings can often be seen to offer customers access to the benefits of the product, but remove the need for ownership. For example, automotive companies such as Mercedes-Benz have experimented with the sale of "transportation" by offering customers the opportunity to exchange their vehicle for another of equivalent price many times during the life of a service agreement.

This means the customer can drive a different car according to their mood as opposed to owning the same one for many years. Rifkin (2000) describes this as the evolution of goods into services and sees this as part of a wider move from the age of ownership to the 'age of access'. He argues that in the 21st century, both consumers and companies are more likely to demand access to services than seek ownership of products, formerly the biggest indication of status and wealth. For example, 'voicemail' services are now more popular than dedicated answering machines, which consumers purchased in the past. If customers can gain access to the service, without owning an answering machine, then they gain the benefit of the service without the hassle of owning the product (Rifkin, 2000, p88). The change in business model which results from offering a service was described in the introduction. Essentially, when a manufacturer makes a product-service transition, they move away from selling ownership of the products they make. Instead they retain ownership of the product, controlling who can use it and, most importantly, who can profit from its use and maintenance. Customers purchase access to the benefits of the product, allowing them to pay for what they use, perhaps at a higher rate, but without carrying responsibility for the life of the product.

Streams of literature

The writer conducted a multidisciplinary literature review to identify existing knowledge on the transition from IHIP to PSS perspectives. That is, work which researches how and why companies should combine their products and services to maximise the value created for customers. The literature can be classified in different ways, but the writer suggests three streams, which see the transition in terms of a different overriding objective and which, generally appeared in different areas of research before becoming combined in literature reviews such as this one. The three streams are compared and contrasted in table 5.1.

	Stream One: Product-Service Systems	***Stream Two:*** Integrated Solutions	***Stream Three:*** Experiential Services
Objective of transition	Environmental sustainability.	Financial sustainability.	Co-creating value.
Achieves objective through	Combining products and services to provide the value derived from products, while reducing environmental impact.	Adding services to existing products, providing value to customers and generating long-term sustainable income.	Creating an environment which turns provision of services and products into a memorable experience.

table 5.1 – three streams of literature related to product-service combinations

Product-Service Systems

The first stream of literature is Product-Service Systems (PSS). For some time after Vandermerwe and Rada introduced the servitization concept to the European management literature (Vandermerwe and Rada, 1988), the discussion lay dormant. A decade later, the term 'servicizing' emerged in a report for the US Environmental Protection Agency by White et al (1999). This report used the term *servicizing* to describe "the emergence of product-based services which blur the distinction between manufacturing and traditional service sector activities" (Ibid, p2). While this appears very close to the earlier servitization concept, the focus of the report was on the potential environmental, rather than commercial benefits of offering service dominated bundles.

The literature on PSS emerged from a number of policy focused reports, recommending service as a means of reducing consumption, by reducing the need for products. The first such report was published in the Netherlands (Goedkoop et al., 1999) but the PSS concept can be found in similar reports for policy makers in Sweden (Mont, 2000) and the United Nations (Manzini and Vezzoli, 2002). These documents present PSS as a means of creating a "functional economy" where producers take responsibility for products and sell the 'function' (value) to customers (Walter Stahel, in White et al., 1999). This would mean less demand for energy and materials because products are durable, upgradeable and have long life-spans. The aim is to move towards "lean consumption" delivering to customers "exactly what they want when and where they want it" (Womack and Jones, 2005).

Most of the literature on PSS has focused on this aim of reducing consumption, for example highlighting the need for new business models (Mont et al., 2006) and design methodologies (Morelli, 2006). Hockerts (1999) and Manzini and Vezzoli (2002) identified three business approaches which mix products with services to offer "win-win" potential for the provider and customer:

- Product services – providing additional services to support a product that is sold (e.g. maintenance, guarantee, and takeback) to add value to the product life cycle.
- Use services – the provider no longer sells the product, but only its usage, e.g. leasing, renting, sharing and pooling. In this way they are providing the "final results" which the customer wants.
- Result services – offering an "enabling platform" for customers, that is, the opportunity to benefit from the use of material goods. The product is owned and run by the supplier, who therefore has an incentive to intensify and optimise the product's operation and increase its service life.

The PSS concept shifts the focus of a business from designing and selling physical products to a system of products and services jointly capable of fulfilling specific customer demands. For some the primary benefit is the potential to reduce the environmental impact of consumption. Roy (2000) showed the

change in approach to environmental sustainability over time, beginning with attempts to tackle pollution at the 'end of pipe'. Subsequent efforts aimed to make production 'cleaner' and then to design products to be recyclable or less wasteful. This progressed to a lifecycle approach whereby sustainability is considered from the extraction of raw materials through production, usage and then disposal or re-use of products. PSS offers a potential means of creating sustainable solutions by re-orienting unsustainable trends in production and consumption practices (Manzini and Vezzoli, 2002).

For some, the primary benefit of PSS are its potential to reduce the environmental impact of consumption. Manzini and Vezzoli (2002) point out that PSS do not guarantee sustainable solutions but offer a potential means of achieving them.

> *"It is only when a PSS actually assists in re-orienting current unsustainable trends in production and consumption practices, that it can be referred to as a Sustainable Product-Service System."*
> (Manzini and Vezzoli, 2002)

Roy (2000) showed the change in approach to environmental sustainability over time, beginning with attempts to tackle pollution at the 'end of pipe'. Subsequent efforts aimed to make production 'cleaner' and then to design products to be recyclable or less wasteful. This progressed to a lifecycle approach whereby sustainability is considered right from the extraction of raw materials through production, usage and then disposal or re-use of products. Although it is not specifically mentioned, it should be noted that all of these activities are normally conducted by different companies, whose efforts are integrated to create the PSS offering.

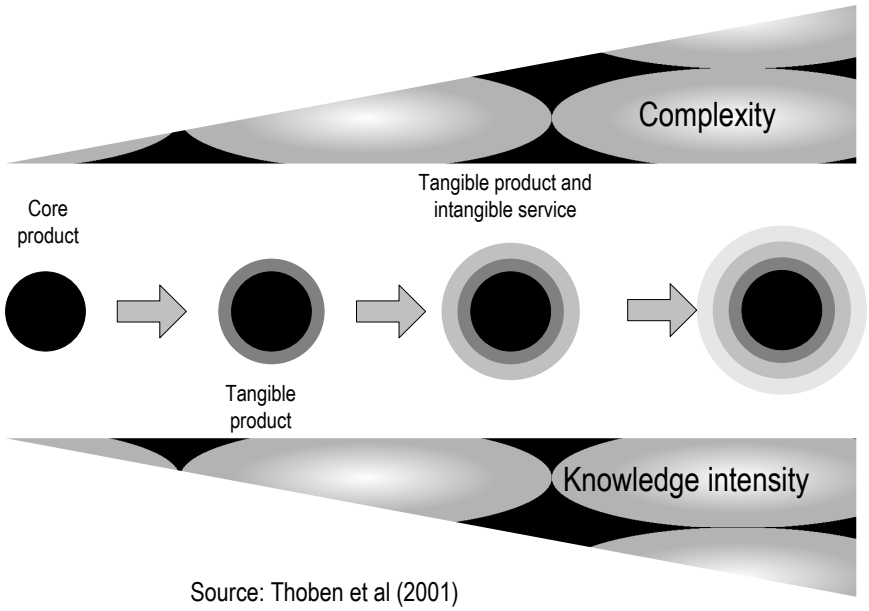
The literature on PSS has tended to be focused on social and environmental issues (Baines et al., 2007) and the aim of reducing consumption. Researchers have presented an argument to policy makers that PSS should be adopted. There is recognition, however, that new design methodologies (Morelli, 2006) and business models (Mont et al., 2006) must be developed for the concept to be accepted by business managers.

Integrated solutions

The second stream of literature, Integrated Solutions, argues that global competition is "shifting the power from the producers to the buyers" (Davis and Heineke, 2005, p126) making it difficult to profit from products alone, so services are seen as a way to guarantee income flows over time. Product quality and performance are no longer order winners but have been relegated to what Hill (2000) refers to as 'order qualifiers' - the minimum criteria for a purchase. Services are now seen as a source of differentiation and added value which some have argued offer more profit potential than product innovation does (Gebauer

and Friedli, 2005). A number of writers have focused on the opportunities for increased profits that services offer to manufacturers (e.g. Mathe and Shapiro, 1993). In fact the management literature is "almost unanimous" in recommending that manufacturers should integrate services into their product offerings (Oliva and Kallenberg, 2003). Services offer a source of competitive advantage in increasingly saturated markets (Mont et al., 2006), in which the installed base of products leaves little scope for sales growth. In the US automobile industry, for example, the ratio of installed base to new units is 13 to 1 (Wise and Baumgartner, 1999). This makes it logical to shift efforts towards after sales services, which are a source of growth for many manufacturing companies. Manufacturers develop knowledge of their products which they can utilise in offering service to customers (Chase and Garvin, 1989). In doing so, they add layers of complexity to their products, 'extending' the core product (Thoben et al., 2001), as represented in the conceptual transition shown in figure 5.6. The next stage in this transition is the integration of products and services to create solutions, for individual customers.

Offering solutions means accepting more responsibility for customers' operations, but profiting by creating value, not simply reducing costs as is often the case with outsourcing (Foote et al., 2001). Solutions utilise the organisation's knowledge and unique competencies to create new value propositions (Sharma and Molloy, 1999). For example, a producer of lubricants can re-define its role to that of increasing the performance and reducing the down-time of customers' machines. This means accepting responsibility for running machines and receiving payment for delivering performance, not simply supplying a product. It is, however, necessary to develop a means of predicting the costs involved, in order to set the price of the offered solutions (Roegner et al., 2001).



Source: Thoben et al (2001)

figure 5.6 – adding 'layers' of service increases the knowledge and complexity in the 'extended' product.

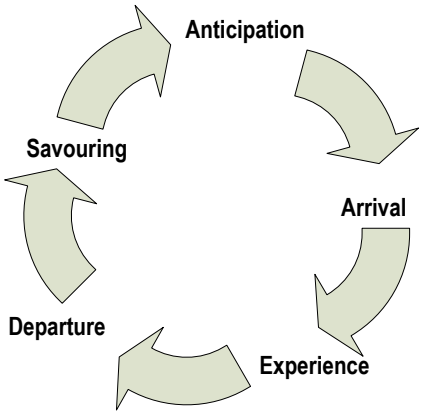
Experiential services

The third stream of literature is found in marketing. The previous discussion has been mostly relevant to the transition from manufacturing to service. Pine and Gilmore (1998) view this as a step on the path towards entering the 'experience economy'. When Vargo and Lusch (2004a) proposed a "*service* dominant logic" to replace the separate concepts of products and *services*, they drew together a large body of literature in the field of marketing. This included work which focused on building relationships with customers as opposed to one-off transactions. This approach sees a focus on the *value* which products and services provide to customers as the "key to the riddle of how to find a sustainable competitive advantage" (Grönroos, 1997).

Another key concept which Vargo and Lusch drew on was that of value co-creation (Prahalad and Ramaswamy, 2004a). This demands a less 'firm-centric' and more interactive model of business. It demands that services and goods be seen as the medium through which companies interact with their customers and demands that the customer's experience be central to every business. Taking this recommendation to its limit, several researchers have viewed service delivery as a performance, in the theatrical sense (Grove et al., 1992). An attempt has been made to derive lessons for service management from the established practice in theatre (Stuart and Tax, 2004) and to transform services into memorable experiences (Pine and Gilmore, 1999).

Applying principles from the behavioural sciences has allowed researchers to identify the key stages of the experience which must be designed (Chase and Dasu, 2001, Cook et al., 2002). For example

memories of the experience will be stronger at the beginning and the end - so the start and end of the service experience should be given particular attention. Voss and Zomerdijk (2007) used this as the basis of their suggestion that developing services should be seen as the planning of a journey. They described the stages of this journey, before and after the service is delivered, as shown infigure 5.7.



Source: Voss and Zomerdijk (2007)

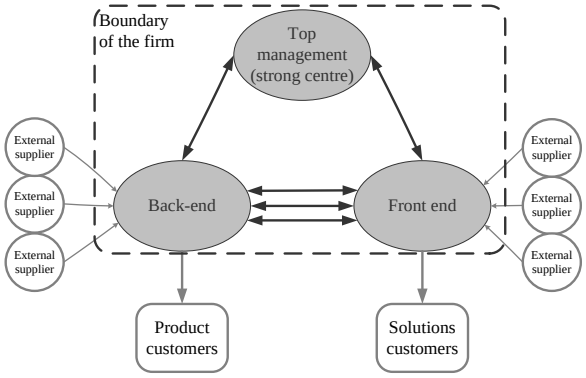
figure 5.7 – stages to be designed in the creation of a service experience.

Writers who describe the design of services as an experience often insist this approach applies equally in business to business as for business to consumer services (Dunn and Davis, 2003, Prahalad and Ramaswamy, 2004b). The majority of companies they use in examples and case studies, however, deal in consumer markets, for example theme parks and 'destinations' such as Disneyland and X-Scape (Voss and Zomerdijk, 2007), consumer products or web-based services such as Lego and Napster respectively (Prahalad and Ramaswamy, 2004b). It can therefore be argued, that, while the concepts are similar, 'experiential services' are a more suitable form of PSS for consumer markets, but that 'solutions' are generally more applicable for industrial markets. In this section we have identified different types of PSS and their relationship, from the literature. In the next section we discuss the organisational dimension involved in creating and delivering these PSS. There are a number of motivations for moving into service, some of which will be described. The literature can generally be seen in terms of two streams, which have now begun to converge. The first relates to Product-Service Systems (PSS), a concept which emerged from a number of policy targeted reports and sees the product-service transition as a means of achieving environmental sustainability. The second stream examines the financial motivations and is therefore more relevant to business. It can be related to two types of combinations, the first being described as the 'extended product' and the second often referred to as. The motivation for making the transition differs, but the literature can be seen in two streams. The first sees services as a

means of creating a competitive advantage by adding value in the customer's view and making products more difficult to imitate, creating a "win-win situation" (Davis and Heineke, 2005). The second sees services as potentially replacing products and is concerned with environmental, rather than financial motivation.

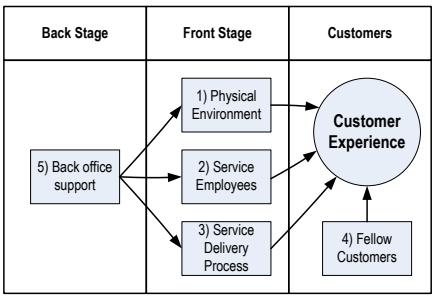
5.4 Designing the Product-Service Organisation

The previous discussion has centred on defining value propositions and identifying types of product-services to fulfil requirements. Creating these product-service offerings, however, can require major changes in the way a company is organised. In the literature, some of the organisational changes required to offer integrated solutions are identified (Sharma and Molloy, 1999, Foote et al., 2001, Galbraith, 2002). For manufacturing companies, notably IBM, the approach presented in figure 5.8, is recommended in the literature. It involves the manufacturing operations becoming the basis of the 'back-end,' which continues to make products for direct sales to customers. A new 'front-end' is added which is more customer facing and builds customised solutions around these manufactured products. In IBM's case, credibility is demonstrated through its impartiality in using rivals' products when these are the best option for the customer.



Adapted from Foote et al, (2001), Davies (2006)

figure 5.8 – a recommended organisational approach for providing solutions.



Source: Voss and Zomerdijk (2007)

figure 5.9 – the focus of organisational design for experiential services.

Re-designing an organisation to create experiences also separates the "front-stage", or customer facing parts of the business, from the operational, "back-stage" parts. This can be traced back to Shostack's (1982) "line of visibility" as well as incorporating a theatre metaphor which sees employees as 'actors' and customers as the 'audience' (Pine and Gilmore, 1998). In this case, 'stage' is taken literally as the

environment for performing a service. Voss and Zomerdijk (2007) identified five areas of the service organisation to be designed in order to create an experience, shown in figure 5.9.

Developing a framework

The result of the literature review was to identify steps in the design of product-service offerings. The process of designing and developing a PSS is proposed to consist of three stages of defining, designing and delivering value. These encompass the design of the product-service offerings, but also identify some of the organisational challenges, in terms of designing the organisational network to deliver product-service offerings. A useful concept in this respect is that of the Virtual Enterprise (Davidow and Malone, 1992, Camarinha-Matos, 2004, Bititci et al., 2005). This is a network of collaborating companies, functioning as a "single, temporary company" (Khalil and Wang, 2002) to act on a particular opportunity. In table 5.2, a list of organisational implications of PSS is presented. While this is not an exhaustive list of

Defining value	***Designing value***	***Delivering value***
▪ Value in use is defined independently of products or services. *(Levitt, 1960, Vandermerwe and Rada, 1988, Manzini, 2001, Thoben et al., 2001, Baines et al., 2007)*	▪ Value can be created by designing products and services in combination. *(Shostack, 1982, Lovelock, 1995, Ramaswamy, 1996, Roy, 2000, Manzini and Vezzoli, 2002, Morelli, 2003)*	▪ Delivering value through PSS requires management of the organisation and may demand external partnerships. *(Normann and Ramirez, 1993, Hayes, 2002, Cook et al., 2006, Mont et al., 2006, Ward and Graves, 2007)*
▪ Defining value for customers/stakeholders is the starting point of PSS design. *(Woodruff, 1997, Payne and Holt, 2001, Mont, 2002, Vargo and Lusch, 2004a, Donaldson et al., 2006)*	▪ Services should be designed around the customer experience including sensory design of the environment. *(Bitner, 1992, Grove et al., 1992, Pine and Gilmore, 1998, Chase and Dasu, 2001, Stuart and Tax, 2004, Candi, 2007, Voss and Zomerdijk, 2007)*	▪ Depending upon complexity, a PSS may be delivered by a single firm or demand a network, where all but core-competencies can be outsourced. *(Mathieu, 2001, Galbraith, 2002, Davies, 2003)*
▪ Defining customers' activities is the basis for solutions, which are more profitable than product sales. *(Sharma and Molloy, 1999, Wise and Baumgartner, 1999, Brown, 2000, Vandermerwe, 2000, Correa et al., 2007, Karlsson, 2007)*	▪ Organisational networks can be designed to share capabilities and jointly create value *(Achrol and Kotler, 1999, Araujo and Spring, 2006, Lusch and Vargo, 2006, Agarwal, 2007, Smart et al., 2007)*	▪ A network can be created by defining required activities, selecting and then managing partners to undertake them *(Foote et al., 2001, Lau and Wong, 2001, Sheridan and Bullinger, 2001)*
▪ Risks and economic potential are hard to predict but new pricing models are essential to ensure profitability of PSS. *(Roegner et al., 2001, Oliva and Kallenberg, 2003, Windahl et al., 2004, Gebauer and Friedli, 2005, Tukker and Tischner, 2006a, Neely, 2007)*	▪ These networks should be designed concurrently with the product and service. *(Boardman and Clegg, 2001, Aurich et al., 2006)*	▪ Performance measures are needed for both organisational networks and service innovation. *(Voss, 1992, Bititci et al., 2005), 2005)*

table 5.2 – some of the organisational challenges of designing product-service organisations are identified across various streams of literature

literature sources or issues, it contributes to the understanding of the design challenges, and suggests that the organisational issues are not fully addressed by the existing literature.

5.5 Case study research

To explore the organisational issues which were identified in the literature review, case studies of two companies were conducted, as described in chapter 3. These two companies were regarded as being at some stage of a product-service transition. The first company had developed a service to capture customers in a very competitive market while the second company was changing its approach to product development as a direct result of its main customer altering its purchasing procedure to demand services. In both cases, the requirements of the product-service offering place new and unfamiliar demands on the design and development of products. The result is that not only must products be designed differently, but the added service element demands that the organisation must be changed in some way. The cases illustrate that there are challenges involved in servitization, which must be identified, considered and addressed. What appears to be a customer driven transition raises issues for operations managers. The approach taken was discussed in more detail in chapter 3, but the case companies themselves are described here. For both of these, the product-service challenges are investigated along with the organisational implications of the product-service business model.

Company A – Aircraft engines

The first case describes the network of partners required by a manufacturer of aircraft engines, to ensure that faults can be diagnosed and repaired anywhere in the world, before they become a problem and result in downtime.

Background

The company is a successful producer of aircraft engines for both defence and civil aerospace applications. Competition for the civil market is between three large companies, who compete for airlines to specify their product be integrated into the airframes of the two major producers. The result is intense competition, for the same customers, on the basis of products which are required to meet identical specifications. R&D expenditure is high and results in technology that provides a competitive edge, but the technology of products alone is not seen as a sufficient source of advantage and the company is focusing its efforts on service provision.

The company previously considered itself a manufacturer but gradually grew its services, which are now seen as the key to future success. Over time, the potential to profit from after sales service was recognised. This function has expanded from selling spare parts, to repairing engines to selling 'power' rather than the engines which provide it. By leveraging knowledge of the product, its usage and customers, the company is now able to offer a service which guarantees a certain number of flying hours, minimising downtime, and thus providing long-term income for the company. This is an oft cited example of PSS, whereby the engine is owned by the producer and its functionality guaranteed over the life of an agreed contract.

Product-Service

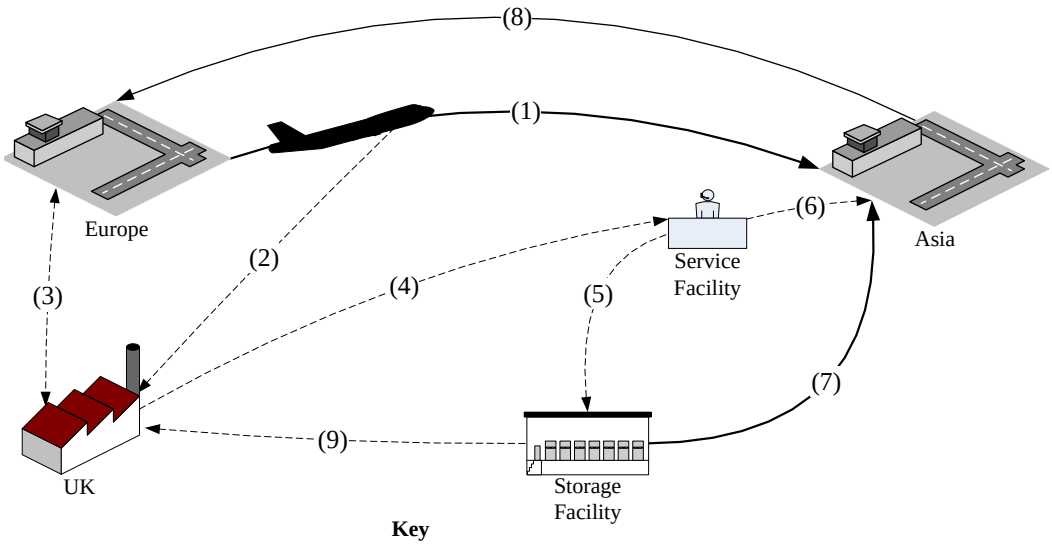
Although the designers and engineers continue to design and make the same engines, the company now focuses on selling the output of these engines. Responsibility for and ownership of the product is retained, while the service is sold. This places new demands on the product, to be considered at the design stage. The major difference is that it is now more important to extend the life of the engine and reduce the amount of repairs required, since this is now a cost, not a source of income. Products being designed to fill future orders will be required to last longer and require less maintenance. While this sounds straightforward, the designers argue that "we can make it last twice as long, but it will be twice as heavy" (case company interviewee, February 2008).

In the past, when designing the product (engine) alone, performance characteristics were optimised according to certain usage requirements. Altering one requirement, such as the length of service intervals, will change the overall specification of the product. Due to the timescales involved in product development, however, the service must now be sold with engines which were designed to meet different performance specifications. Since existing products were not designed with the new service contracts as the starting point, performance may no longer be optimal. Further, approval is required from the aviation authorities, making it very difficult to introduce changes during the lifetime of a product.

An immediate change which has been introduced by PSS is to make the engines more 'intelligent', by incorporating condition monitoring systems to detect potential problems. This provides a rich source of data on the products in use, which can potentially be utilised in designing future products. It also increases the company's knowledge about customers' use, which helps in designing the service and the engine.

Organisation

The aim of the PSS induced changes to the product, is to reduce down-time, by detecting and preventing problems. Any loss of functionality represents a loss for the company, since it receives payment on the basis of up-time delivered. The importance of maintaining function was demonstrated through an anecdote regarding an employee being sent abroad, carrying an important component in a suitcase. The cost of losing this employee for several days was acceptable when weighed against the risk of losing uptime for an important customer. This highlights the importance of uninterrupted access, but also suggests the organisational challenges involved. Customers are based across the world and, by their nature the products are dispersed globally. Whereas scheduled repairs can be made in specified locations, tackling unexpected problems requires a global reach.



1) a plane makes a scheduled flight from Paris to Hong Kong.
2) the engine monitoring system detects a problem and informs the manufacturer's headquarters.
3) information from engine's last scheduled check is requested and received.
4) a request for a repair is made to a local service partner.
5) a request for required components is made to a storage facility.
6) scheduling of maintenance work including people and parts required.
7) components required for repair are transported to airport.
8) following repair, the plane makes a scheduled return flight.
9) a request to replenish the stock of components is made to the engine producer.

figure 5.10 – minimising an aero engine's downtime requires a global reach.

The company's vision is to have faults diagnosed and repaired anywhere in the world, before they can cause disruption. For example, if a potential failure is identified in-flight, the aim is to have the parts and the appropriate personnel in place when the aeroplane lands to repair it before it fails. A visual representation is provided in figure 5.10figure 5.10, which shows a typical process that the company would aim to manage smoothly. Doing so requires them to either own facilities across the world, which could repair engines at short notice, or to access the capabilities of local partners. One of the major

challenges which emerges is how to ensure that these partners deliver the same level of service quality and performance that the company would deliver itself. External partners are trusted with the responsibility for delivering the service and, in the customer's eyes, are employees of the company. This means that managing the performance of partners is vital. The company can save costs and cope with increasing demand by outsourcing production. On the other hand this requires far greater attention to the design, re-design and integration of the supply chain.

Company B – Defence aerospace

The second case addresses the organisational complexity required to cope with the added responsibility a company undertakes to deliver value in the form of 'capability' rather than products.

Background

Company B is a developer of complex, hi-tech products, including military aircraft, for which it receives orders from the UK government's Ministry of Defence (MoD). The development of these products is itself a complex task, requiring collaboration between partners who are specialised in the development of key systems and components. For example, in typical projects, major partners supply engines, weapons systems, or electronics systems which are integrated into new products, developed to meet specifications. The MoD is the main customer, which previously separated the two functions of procuring these products from supporting them, through two separate organisations. Contracts for design and development were placed by the procurement organisation while the support organisation would place support contracts.

Even though Company B previously developed and supported products, these two functions would be separated, with no incentive to integrate them. Products were not designed to be easily maintained if this was not specified and paid for by the customer. Since maintenance was paid for separately, offering support services was another key source of income for the company. A recent restructuring in the MoD has seen the procurement and support functions combined within the same organisation, which now offers single contracts for design, development and support. There has been a progressive increase in the amount of responsibility given to suppliers by the MoD, reflected in the types of contracts offered. Traditional contracts, covering the design and development of specified products gave way to "spares inclusive" contracts as the service element increased. The next step was availability contracts which demand mission ready equipment, meaning responsibility for the development of the products and support to ensure uninterrupted functionality. Now, the industry is moving towards Through Life Capability

Management (TLCM) contracts, which specify only the capability or 'value' required but are less explicit in the detailed technical specifications of the products which deliver it. An example of a TLCM contract is the provision of the capability for pilot training. The company providing this capability could produce, maintain and refuel aircraft on an airbase, ensuring their availability when required for instructors to train pilots. An alternative could be to reduce the number of aircraft and provide flight simulators instead of or in addition to physical aircraft. If the required training capability is provided, then the customer is less concerned with how it is achieved, but the provider must deliver the capability within the agreed budget. The company thus provides an integrated solution over a long period of time. This often involves many partners in both the development and delivery phases, including civil and military partners in delivery.

Product-service

The availability and capability contracts have greatly altered the development of products. It is now necessary to design products with the requirements of maintenance and support in mind. This alters the design process by adding greater requirements and constraints, so that product performance is not the only consideration. It becomes essential to estimate future costs accurately, since these can no longer be passed on to the customer. In the past, if a product was to be upgraded to incorporate new technology, for example new fuel systems, this would be paid for by the customer. Now the producer is required to plan for this and incorporate new technology into its products. Failure to predict future usage and the availability of technology may incur costs and, since the price is fixed at the beginning of the contract, will

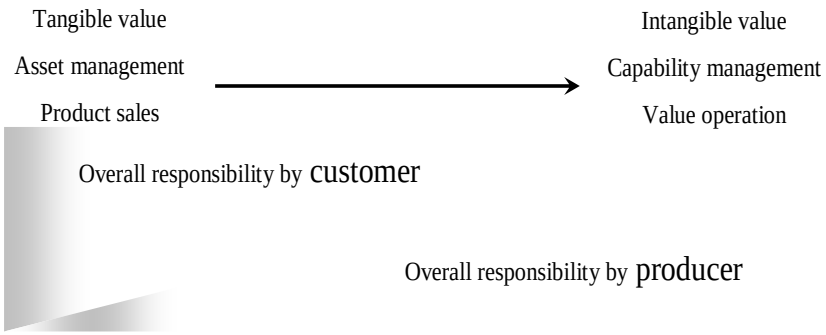


figure 5.11 – Through Life Capability Management increases responsibility on the producer (case company interviewee).

reduce profitability.

These new contracts shift the responsibility and costs over the lifetime of the product, from the customer to the producer. These contracts would not be for the production of a particular model of aircraft, but for "the capability to strike with offensive force, 5,000 miles from base". There is scope for alternative means of delivering this capability, but at present, a bid for such a contract would be based on aircraft either

presently available or under development. A major change is the added requirement to provide spare parts, fuel, weapons and personnel to maintain the functionality of the aircraft. If the aircraft has a range of only 4,000 miles this also necessitates the capability to refuel them in flight. Providing capability thus requires the producer to move closer to the front line and for civilians to take on responsibilities which were previously military concerns. Although civilian personnel do not pilot aircraft in battle, they may now be required to operate facilities on the airbases the aircraft take off from. Although the products this company develops are among the most technologically advanced in the world, the complexity involved in delivering a PSS for a TLCM capability contract means that "product design is the simple bit" (case company interviewee, June 2008).

Organisation

TLCM contracts offer potential financial benefits but only if the organisation has the infrastructure to cope with the increased responsibility placed upon it, as indicated in figure 5.11. In one recent project, the cost of developing the supporting infrastructure outweighed the cost of developing the product by around ten times. This infrastructure includes many responsibilities which are out-with the traditional scope of the company's operations. It may have core competencies related to the design of highly complex products and the integration of cutting edge technologies, however, transportation of fuel to remote airbases in potentially hostile territories, may not be among its capabilities. It signs long term contracts, lasting several decades, to deliver this capability. These contracts create problems in meeting current and predicting future demands

The solution has been to create virtual enterprises (VE) which consist of several partner companies operating as a single organisation to co-ordinate the creation and delivery of the required capability. Collaboration is between a temporary consortium of partners which forms to bid for a contract and, if successful, to develop and deliver the capability demanded, through PSS development. The partnership is dissolved at the end of its function, but the partners may collaborate again in future projects. Additional partners are identified by defining the required capabilities, assessing potential partners and selecting the most appropriate ones. Traditionally each organisation would work independently, sub-optimising to maximise their own profits and reduce their costs. The new approach creates dependence between all participants and results in suppliers being included throughout the product design, development and delivery process.

The VE involves different companies sharing resources and knowledge throughout the process. During the delivery phase, civilian organisations must collaborate with each other and with military personnel. They are required to use military facilities such as bases and hangars and co-ordinate logistics, such as delivery of supplies, with military personnel. In potentially volatile and dangerous situations, ensuring the contract is profitable is not straightforward, given the fixed price. The complexity involved in this extreme case serves to highlight the challenges involved in predicting the costs and risks of the PSS. It also demonstrates that delivering the value customers demand requires consideration of the capabilities required and how to access them.

Summary of cases

In both of the cases presented, there is a shift from manufacturing products to delivering value to the end user. The implication for both companies was to extend the boundary of the organisation to access the capabilities of external partners. In the first case the partnerships are relatively stable and therefore the company puts resources and effort into the development of its partners. In the second case, however, the partnerships have more of a temporary nature and exist for the duration of a specific project.

	Define value	*Design value*	*Deliver value*
Company A	Value is defined by the output of the products, while ownership is retained by the producer.	Current products are designed with condition monitoring. New products will be designed to last longer and require less maintenance in order to reduce lifetime cost.	Maintaining the product's function in order to ensure value is delivered requires management of a global network of local partners. Measuring and managing partners' performance and quality are vital.
Company B	Value, or capability, is defined by the customer, not specific products. Assessing the risks and costs of the added responsibility is vital.	The complexity of products and scale of infrastructure make it necessary for product-service and organisation to be designed simultaneously.	Delivering value requires collaboration between several partners managed as a single organisation and sharing military facilities.

table 5.3 – the cases provide examples of organisational challenges.

These cases helped in the identification of organisational challenges not addressed in the literature. Some examples of issues which emerged are given in table 5.3. From these two cases we can see two different types of organisation. For company A, the organisation can be designed independently of the product-service, since the development of the product and delivery of the service involve different partners. Company B, however, works on projects in which the design of the infrastructure is tied to the design of products and therefore the product, service and organisation must be designed simultaneously.

5.7 A framework for product-service organisations

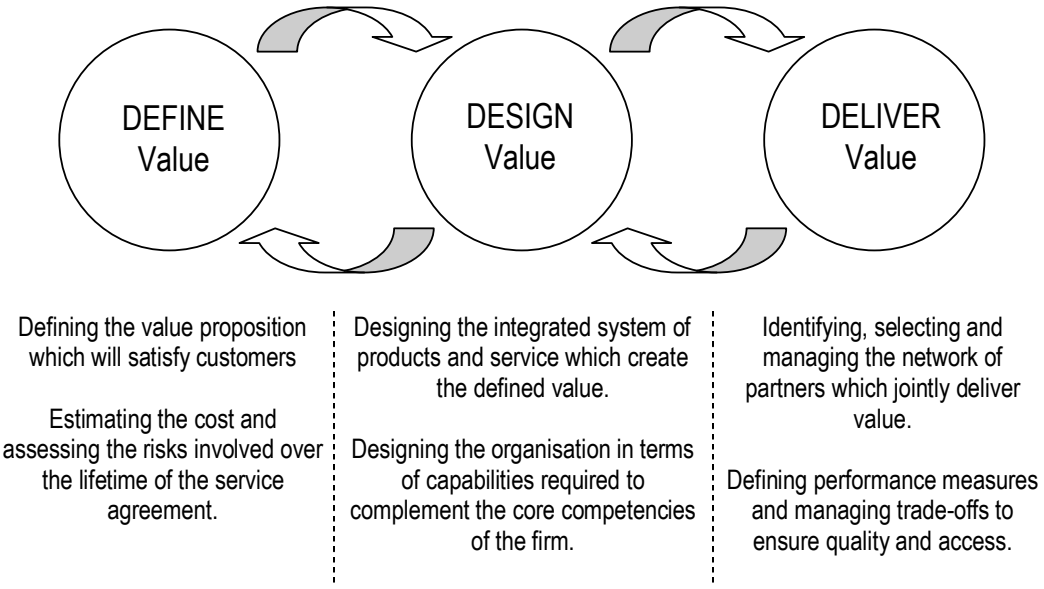


figure 5.12 – a framework describing generic challenges of PSS design

This chapter reported the result of a study of design in product-service organisations. It began with a multidisciplinary literature review, which led to the development of a framework. The gaps in this framework were explored using case study research, resulting in a process, featuring three stages, with key challenges identified at each stage, as shown in figure 5.12. This process encompasses the iterative, multi-disciplinary and collaborative process to create and deliver value to customers.

In the past, attempts have been made to adapt traditional product design methodologies to the development of services (Hollins and Hollins, 1991, Ramaswamy, 1996). When developing **PSS**, rather than 'services', it has been recognised that a new methodology is required (Morelli, 2002). This framework contributes to knowledge by incorporating the requirement for external collaboration into the process. The major difference, compared with traditional product development is the complexity added by the service element, which demands increased organisational complexity.

The framework helped to refine the focus of the research and identify that this organisational complexity was a topic for further investigation. While the majority of the product-service literature to date has been case based, there is still scope for further case research to understand how a company organises its design processes and manages its interaction with partners to create and deliver value. In the following chapter, a case study will be described, which explores a product-service organisation in more detail and investigates what kind of services they deliver, how they design their products and how they structure the

organisation for product-service. The following research questions arose from the research described in this chapter and will be explored in the next:

How does a product-service transition take place and what is its outcome?
In chapter one, the benefits of a product-service transition, as identified from the literature, were presented. The servitization literature makes assumptions about how this transition takes place, for example that it happens according to the plans of a manufacturing company's strategic managers. Additionally, there are many examples of product-service offerings in the literature, but they are not always explored in detail in the context of their market.

How are the products at the heart of a product-service offering designed?
Another implicit assumption made in the literature is that manufacturers can simply bundle their products with services and reap tremendous financial rewards. If this is the case, then perhaps product design is unimportant, since products are treated as commodities and the manufacturer will focus on capitalising on its services. Another perspective is that product must be designed for service delivery, so the way they are designed must completely change. An important question for this research concerns the process used to design and develop products and how this is shaped by the requirement to sell services.

How is the organisation structured to develop product-service offerings?
In this chapter, the structure of both internal and external organisations has been described as an important topic which requires further investigation. The literature in this area is somewhat limited, although there seems to be consensus on the need for a front/back structure with dedicated customer-facing and product-facing teams. How these teams are organised and structured, particularly in the context of designing and developing product-service offerings is another important question.

How is design used in a product-service organisation?
All of the above questions relate to different aspects of the company's design, namely the offerings it designs, the process used to design them and the structure of the teams involved in this design process. Following the approach to design activities described in chapter 4 and Roy and Riedel's (1997) approach to defining the role of design in products, another question is what the role of design in this company. In particular, how this role has changed or is changing is a topic to be investigated in this research.

Chapter 6
Design in a product-service organisation

"We don't sell products, we sell the promise of a solution."
(Executive, Supply Chain, November 2008)

This chapter describes a case study which brings together the two themes of this research – design and product-service organisations. The methodology for data collection and analysis were described in chapter 3 so this chapter describes the case company and the results of the analysis. The case company is a producer of aero-engines, offered to customers as part of a product-service offering. Data were collected through interviews with 23 employees of the company, involved in different areas of product development and service delivery. The case describes the company's offerings and different perspectives on its product-service transition; the process used to develop the products at the heart of the offerings; the organisational structure in place to design and develop these offerings; and examines the role of design in the company. The analysis brings together the frameworks developed in chapter 4 and 5 to examine the role of design in a product-service organisation.

Relevant Publications

1. **Beltagui,** Pawar, Riedel (2010) "Designing in a product-service organisation", 17th International Annual European Operations Management Association conference (EurOMA 2010), Porto, Portugal, 6-9th June.

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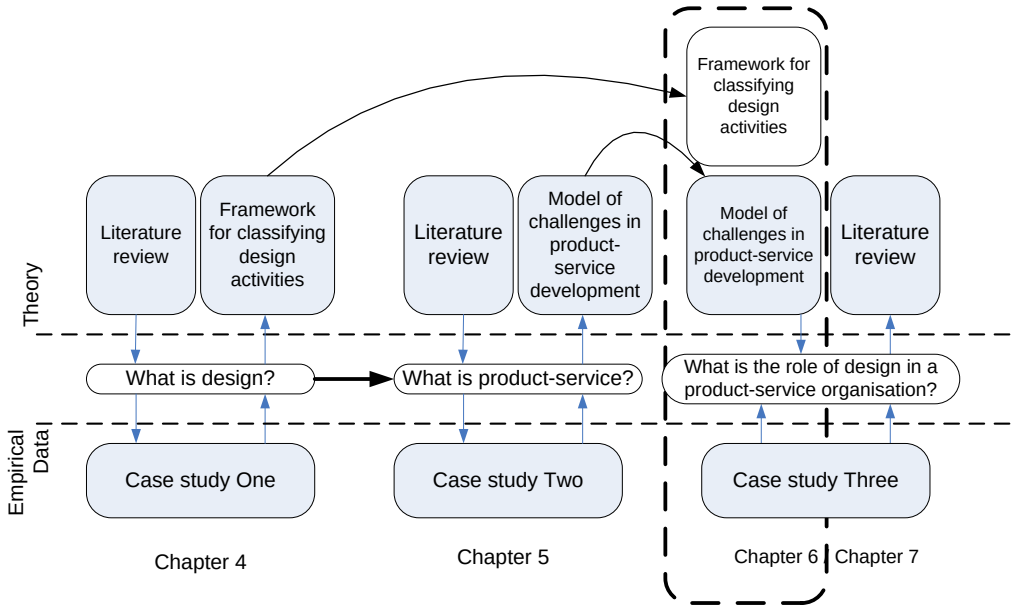


Thus far, the topics of design and product-service systems have been examined separately, with the links between the two topics identified throughout. As described in chapter 3, a case study of the design process within a product-service organisation will now be presented. This chapter builds on the contributions of chapter 4 and 5, which can be summarised as follows:

- Design is the creative process of developing a prescription or model to be embodied in a finished offering.
- Design activities can be classified as product, business-facing and customer-facing design activities.
- Developing product-service offerings typically requires attention to the product, service and the organisation which creates and delivers the offerings.
- Developing product-service offerings can follow three stages of defining, designing and delivering value to customers.

The case also builds on the understanding of product-service design presented in chapter 5 – namely that the product, service and related organisation are simultaneously created through a process of defining, designing and delivering value to customers.

The case study focuses on design activities within the company's New Product Introduction (NPI) process and understanding the input of various functions to this process. After a brief introduction to the

company, the analysis of the interviews is presented in the form of a discussion around the four research questions described in chapter 3. How does the industrial context influence a product-service transition?

- How does a product-service transition take place and what is its outcome?
- How are the products at the heart of a product-service offering designed?
- How is the organisation structured to develop product-service offerings?
- How is design used in a product-service organisation?

6.1 Aero-Engine Co.[1]

The company is a very large and successful maker of gas turbine engines, used in a number of different sectors, of which the civil aerospace market is the most publicised and contributes the greatest share of revenue. In this market, the company has two main rivals, based in the USA. Each of these companies develops engines for use on aeroplanes produced by air-framers in Europe and North America. R&D investment is intensive and protection of intellectual property is used strongly. In addition to the high cost of materials and manufacturing, intellectual property, in the form of patented technology, represents an almost insurmountable barrier to any potential new entrants. At various stages in the past, each of the three companies has had a technological advantage over its rivals, yet this advantage has always been temporary (Bonaccorsi et al., 2001). Although its products are considered by many to be technologically superior to those of its rivals, Aero-Engine Co's products alone are now seen as insufficient to create a sustainable competitive advantage. Additionally, the reliability of the products, and the cost of repairing them, have often been less attractive to customers than rival products.

The company is presented to the public and marketed to its customers as a service business. In evidence, the percentage of revenue from services compared to manufacturing, which has been over 50% and growing for some time, is cited. Despite this, however, the company's success is based on the products it designs and its management of their manufacturing. While its rivals offer services such as finance, independently of their products, all of Aero Engine Co's services are integrated with their core products. This means that their manufacturing and service operations are closely linked and the development of new products, far from being less important than service, is seen as their "bread and

[1] In the interests of anonymity, a pseudonym has been used in place of the company's real name. Job titles of interviewees have, likewise, been disguised.

butter" (Executive, Logistics, May 2009). This case study is concerned with the management of the design process and the role of design in creating product-service offerings in Aero-Engine Co.

The company's portfolio of products are built around its technology, with the aim of developing technology once and using it for several applications. The core technology utilises a product architecture which is more technically complex than rivals and is considered to be a major source of competitive advantage. Products utilising this technology are used in military and civil contexts, to power aircraft, ships and power plants. The case study reported here concerns the civil aerospace applications. Staff who were interviewed were all involved in the design, development, production, servicing and marketing of engines for civil airlines, although several had experience of other areas, which enabled them to make comparisons.

6.2 How does a product-service transition take place and what is the outcome?

The transition undertaken by manufacturing companies, to become a product-service organisation was discussed in chapter 5. This is essentially considered to be an evolution through a number of stages, from 'pure' manufacturing, with service as a necessary cost of business, to increased service provision as a valuable offering in its own right and finally to integrated packages of product and service which create a unique form of value for customers. The reasons for making this transition were also discussed, for example to reduce risks and responsibility for customers, who would be able to pay only for what they use and focus their efforts on their core business; and to reduce the volatility of revenue for the producer, who could achieve more predictable long term deals and build relationships with key customers. An assumption emerges from these descriptions and justifications, which suggests that a product-service transition is normally the result of a deliberate, senior management strategy. This case study explored a company in which such a transition has occurred over a number of years. The company is publically presented as a service company, with growing service revenue and large future orders for service contracts. An image has been created of a service company which sells product-service offerings and not 'just' engines. This section will explore the nature of the company's service offerings and the product-service transition it has made, through the descriptions of interviewees.

Most of the interviewees, particularly those with a background or current role in engineering, expressed pride or awe of the technical sophistication of the company's products. One interviewee described a process for bonding components which required forces equivalent to "two elephants rubbing together until they become fused" (Executive, Supply Chain, November 1998). He went on to describe components which operate at a temperature higher than the melting point of the material, due to the coatings and cooling methods used. Another interviewee proudly displayed customised tools developed to cut extremely complex components (Manufacturing Engineer, Design, April 2009). He showed drawings of components to showcase the ingenuity of the engineers who developed these products. For many, the ingenuity and technical excellence of products is what makes the company successful. And the status of engineers who design these products remains high, regardless of the company being a service organisation.

Product-service transition

Having occurred over many years and accompanied a significant expansion in the workforce, the company's product-service transition began before many of the present staff joined the company. One interviewee stated that developing products for product-service offerings was all he had known since joining the company (Supply Chain Manager, SCU 5, April 2010). For those who had been present for longer, the transition to service offerings was described as a strategic move, or in terms of the economic benefits of aligning goals with customers'. One interviewee described the transition as a move towards a higher value offering, arguing that the company has chosen to move closer to the end user, but not too far (Executive, Logistics, May 2009). He described a chain from component suppliers, through engine and airframe suppliers, to airlines, travel agents and passengers. The capabilities of the company would allow them to move some way up this chain but it would probably be unwise to go as far as selling transportation to passengers. The key factor which would enable a transition is the technical competence, with the engine considered to be the most technically sophisticated part of the aircraft, something which another interviewee agreed with (Executive, Marketing, April 2010). He described the transition in more detail than any of the other interviewees, but unlike some others, seemed clear that the transition had been a largely opportunistic evolution.

The story told by this interviewee begins at the point where the company had overextended itself in the development of a new product architecture and was in a very weak market position. He claimed that the company began offering a kind of rental service, in the early 1980s, with airlines paying for the flying time

of engines and not maintenance. The stumbling point was the ownership of aircraft, since many aircraft were leased by airlines and owned by financial institutions, who were not too keen on owning an engine without what was considered the most valuable and technically complex part. In the following years, product sales began to grow and maintenance services became a more significant source of revenue, resulting in an expansion of the company's facilities

> *"…as our market share grew, our capability to overhaul engines grew as well. So we started to get involved with diffferent operators around the world and that kind of sowed the seeds for our joint ventures then to spring up, basically all around the world."*
>
> (Executive, Marketing, April 2010)

The real catalyst for the development of a new offering, however, was a request by one airline customer to find "a better way of doing this" (Executive, Marketing, April 2010) in the early 1990s. Their argument was that while they managed a relatively large fleet, the producer of the engines, which carried out maintenance of a global fleet, should have much more experience and product knowledge, enabling them to maintain engines more effectively than customers. From this point, the service offerings have grown out of what was once simply a maintenance agreement to far more sophisticated and higher value offerings.

From the description above, it is unclear why airlines were unconvinced by the 'rental' type offerings in the 1980s but are now more keen to enter into service contracts. One issue is the nature of competition in the airline industry and how this has developed in recent years. While in the past the industry was dominated by large, national carriers, recent years have seen the rise of low cost airlines, which operate on a very different business model. Large airlines traditionally owned facilities and employ staff, including engineers who deal with engine maintenance. As British Airways has discovered when attempting to reduce its staff costs (Milmo, 2010), these employees have a relatively strong position and therefore cannot be easily replaced by services from an engine manufacturer. More recent entrants into the market have focused on the operations of delivering efficient, low cost travel. It can be expected that such airlines would see the benefits of outsourcing the maintenance of their engines, making a product-service offering seem like an attractive and accessible proposition. Windahl and Lakemond (2010) identified that accepting integrated product-service offerings often means a customer losing knowledge of and influence over the processes involved in these offerings. In this case, airlines would sacrifice capabilities in engine maintenance when allowing their engines to be maintained by the manufacturer. For traditional airlines, which have such capabilities, this is a greater and more complex sacrifice than for a low cost airline which operates on a business model that actively seeks to reduce commitments to such capabilities. The airline

industry, therefore, has changed in recent years and created a situation in which there is likely to be increasing demand for services. For Aero-Engine Co., having the capabilities to offer services has given them the ability to exploit this demand.

Product-service offerings

Interviewees discussed the commercial applications of the company's civil engines, which are used in both commercial airline jets and privately owned aircraft. They discussed their understanding of the product-service offerings built around these engines, although as will be described later, most have very limited first hand knowledge of customer interaction. Interviewees described a novel revenue model, bringing regular payments over the lifetime of an engine. This replaces the old model of high development costs being recouped through occasional and often unpredictable revenue from spare parts. This benefits the company by providing a constant revenue stream, while allowing the customer to pay for only what they use, rather than the whole engine (Supply Chain Manager, SCU 1, April 2009). What was described as "the previous model" (Executive, Supply Chain, November 2008) meant unpredictability in terms of aftermarket revenue. Although some revenue would be expected from services or spare parts, service revenue was to some extent "hoped for" rather than accurately predicted. Additionally, the millions invested in product development would need to be recouped "before someone else makes a cheaper one" (Executive, Supply Chain, November 2008). Similar accounts were given by other interviewees, who clearly saw a distinction between an 'old' product revenue model and a 'new' service revenue model.

There are still engines sold on a product basis, particularly for corporate jets, where the product-service package is offered but not always taken up by customers (Executive, Supply Chain, April 2009). From the perspective of Repair and Overhaul (R&O) staff, the transition is evident in the proportion of repairs they conduct which are under service contracts. In the R&O shop at the company's UK headquarters, for example, approximately 70% of work is on engines under the new model, while in other plants in the Far East, the figure is closer to 100% (Logistics Manager, Repair and Overhaul, April 2009). Yet this is to be expected since customers who decide to purchase engines under the product model may do so because they have their own repair facilities and staff to deal with maintenance. Under this model, repairs carried out on behalf of customers incur charges for the time of employees and the materials used to carry out repairs and maintenance. Alternatively, customers may carry out their own repairs, if they employ engineers to manage their products. It is unclear – and impossible to ascertain from annual reports and

other public documents – what proportion of the company's products are sold under the old and new revenue models.

Examining the nature of the offerings themselves, the first point of contention is the ownership of engines. Under the working definition of a product-service offering used in this research, it is assumed that the ownership and responsibility for maintenance is retained by the company offering the product-service, while access is purchased by the customer. This understanding seemed to be shared by interviewees whose roles related to product development, as well as those involved in service delivery, i.e. Repair & Overhaul (R&O). In the words of a Marketing Executive, (responsible for marketing activities related to airlines) however,

> *"We're selling a service product. You have to buy an engine to get service."*
> (Executive, Marketing, April 2010)

He explained that the engines belong to the customers, who are then able to purchase a service contract for these products. Indeed customers are strongly encouraged, but not required, to purchase such a contract, to create the mythical win-win scenario. He went on to argue that, while much of the cost involved in the service contract comes from maintenance activity, the nature of the service has evolved from being a "maintenance pension fund" to "selling a pretty sophisticated, integrated package". This integrated package consists of scheduled and unscheduled maintenance and condition monitoring as well as a range of other optional services. These will be explained in the following sections.

Scheduled maintenance

Scheduled maintenance, similar to regular servicing of cars, helps sustain the value of engines in two ways: through the reputational value of the service history and by replacing components to ensure performance is maintained. A car serviced at recommended intervals, by an approved dealer, will tend to have a higher re-sale value than one which lacks the same service record. Equally, an aero-engine which has been serviced by the manufacturer may be recognised as being of higher value than one which has been maintained by the airline. This is of benefit to the airline for long term security, should they decide, or be required to, sell the engine in future. While re-selling engines or aircraft is uncommon for airlines, it is particularly common for corporate jets, which are traded almost as frequently as cars.

Unlike cars, aero-engine components are almost entirely replaced during their life in service. At each scheduled maintenance, the engine will be inspected, components will be cleaned and, where scheduled or required, they will be replaced with new components. This results in a 'saw tooth' effect, whereby the

value of the engine as an asset decreases over time, until new components are added during servicing, restoring the engine to close to 100% of its original value (Executive, Marketing, April 2010). The result is that the original components are all replaced over the lifetime of the engine, explaining why maintenance costs are such a significant cost for airlines and source of revenue for the company. A service contract, offering predictable servicing costs over the lifetime of a product is, therefore, an attractive proposition for airlines. In particular, those such as low cost airlines, which do not have or desire to have their own maintenance infrastructure would understandably be drawn to such an offering.

Having the capacity to overhaul and repair engines on behalf of many customers enables economies of scale, which make offering a product-service package attractive. The attraction for customers includes the access to this capacity and, crucially, the expertise of staff.

> *"you're paying for all those guys looking after your engine, making recommendations, booking that overhaul slot for you two months in advance so that when your engine comes off-wing, we have a spare engine for you to use and we've arranged the transportation for that engine, it goes straight into the shop. And we've made sure that the shops have got their parts ordered, so your engine's in, repaired, out, tested, back to you as soon as possible."*
>
> (Executive, Marketing, April 2010)

The sophistication of maintenance services means that the offering includes scheduling and logistics to minimise disruption. For example, planned maintenance activities are carried out at the most convenient times for the customer. They are scheduled in advance to ensure the repair shops have adequate capacity to avoid delays and parts are ordered in advance to ensure their on time delivery. As can be gathered from events such as heavy snow and volcanic eruptions in recent months, airlines suffer greatly from unexpected disruption to their service. The first part of the product-service offering, scheduled maintenance, therefore seeks to minimise this disruption.

Unscheduled maintenance

Under normal circumstances, maintenance can be scheduled to reduce disruption. As car owners are aware, however, machinery often develops problems in between scheduled servicing, requiring urgent and often costly repairs. The second element of the product-service offering described seeks to make unscheduled repairs less disruptive.

The company offers documentation online to its customers, allowing the airlines' own maintenance staff to carry out minor maintenance, by accessing the appropriate information. If there is any concern, for example an unexplained noise during operation, then the customer's maintenance staff may make use of a boroscope. This is a camera inserted into the engine, described as similar to those used for keyhole

surgery (Executive, Supply Chain, November 2008). The boroscope captures digital images without requiring disassembly of the engine. These images can be compared to the online documentation, with instructions given in a similar, but more sophisticated, manner to a car maintenance manual. If further attention is required, the images can be emailed to a service operations centre, which operates "24 hours, 7 days a week" (Chief Engineer, R&T, April 2009). The service engineers will be available to recommend a course of action, upon viewing images sent by the customer. They may recommend no action, give instructions for a simple repair or initiate a minor repair by the closest certified maintenance hub. This may be in the airport where the engine is presently located, or a local hub operated by the company and its partners. More serious issues may call for an on-wing team to be deployed, in order to make the required repairs as quickly as possible, with the minimum disruption and downtime for the customer. The on-wing teams are "like the AA" (Executive, Marketing, April 2010). They are located in on-wing centres around the world in order to travel to airports when planes land and offer assistance as required.

In extreme cases, where major repairs are required and there a risk of the aircraft being grounded for some time, a lease engine may be provided. The company holds a number of complete engines, at suitable locations around the world, which may be used to ensure that flights can continue while an unscheduled repair takes place. The number of repair bases owned or jointly owned by the company has more than doubled in the last decade or so (Logistics Manager, R&O, April 2009) These bases are located all around the world, as opposed to only in the company's headquarters and traditional locations. This enables the service offered to be global.

Under the old revenue model, the failure of a component was a potential source of revenue, through sales of spare parts. The cost of repairs would be a source of income for the company, meaning they would in fact be rewarded, in the short term, for the failure of their components. Under service contracts, the disruption caused by the failure of components incurs penalties or charges. Additionally, the parts used for repairs are sold at cost price (Logistics Manager, R&O, April 2009) meaning there is no profit on these parts. This makes failure of components in service undesirable and means "aligning our goals and customers' goals better" (Executive, Design, December 2008).

Condition monitoring

In seeking to minimise the disruption of unscheduled maintenance, the third and arguably most crucial element of the product-service offering is the monitoring of products in use. Every engine sold under a

service contract is monitored electronically, using sensors which transmit data several times during each flight. A subsidiary of Aero-Engine Co, based at its headquarters, is responsible for processing all of the data, enabling the company to act upon it. Deviations from normal figures for vibration, temperature, fuel burn, noise etc will be detected and investigated, during or after a flight. If the data show cause for concern, the maintenance actions described above will be utilised, for example an on-wing team may be deployed in time to meet the flight at its destination airport or a visit to a convenient repair shop could be scheduled.

The potential for preventative maintenance or emergency repairs is an advantage of condition monitoring, but the data gained through this approach is of further benefit for both the company and its customers. For the company, the data is invaluable as a resource for improving the performance of future products and this is exploited in the design of new products. It also enables the company to make recommendations to customers on how to improve their utilisation of their products, or to identify misuse and influence the pricing of future contracts. For example, if a pilot consistently uses the maximum power of the engine, this can be identified and highlighted as an inefficient practice.

> *"…So there's been a kind of education that we've had to go through with the customers to say "whilst all that capability is there, you don't need to use it all the time because in the long run its going to be expensive for you".*
>
> (Executive, Marketing, April 2010)

The company is able to educate customers on the best way to use its products, making use of data showing their actual utilisation. In this example, the recommendations are intended to allow the customer to use less fuel to make the same flight, by reducing the thrust used. On the other hand, this monitoring can allow the company to identify misuse, for example when attributing responsibility for engines requiring unscheduled maintenance. Certain pilot behaviours affect the rate of fuel burn, but may equally place unnecessary strain on an engine, which will also be visible. This could allow the company to re-evaluate the length of service intervals and, since decisions will be evidence based, to pass extra costs on to the customer, according to the negotiations and contracts made. In general, a price per hour of flying time is agreed on an annual basis, according to scheduled or predicted flights. Taking into account the knowledge gained from previous interactions with this and other customers, the company can price its offerings appropriately.

> *"…we've moved away from it being maintenance into it being service provision. Then we've got a little more sophisticated with our business structures, how we work the rates out, how we calculate the charges."*
>
> (Executive, Marketing, April 2010)

Finally, the data gained through condition monitoring can be crucial for the design of future products. For example, in the development of a new engine, a list of 100 components, found to contribute most to the cost of the product, were identified. Analysis of data gained from the monitoring of these 100 components, on engines currently in use, formed the basis of a re-design of these components to improve their performance and reduce the cost of maintaining them (Analyst, SCU 3, April 2009). Condition monitoring enables an invaluable source of knowledge, helping to capture customer requirements and transmit them to the design process. One interviewee, responsible for managing the design of a range of parts likened the knowledge gained to the research conducted by automobile companies (Executive, SCU 4, April 2009). These companies emphasise ethnographic research, following families on holiday and sharing their houses to gain insights into customer needs. In contrast, aero-engine customers are considered to have needs which are more suitably measured quantitatively rather than observed qualitatively.

Findings

- The product-service transition in this company was not a straightforward implementation of strategy, but rather involved customer demand and the utilisation of growing resources, which is now rationalised by interviewees as a deliberate process. Additionally, despite the rhetoric, there is a suggestion that the direct impact on many of the product focused parts of the company is limited. The company retains an engineering and product focused culture in some areas.
- In this case, the key to offering a profitable service is product knowledge, since the ability to design products allows their maintenance and management. Monitoring products in use increases product knowledge, further enhancing the design of products and the profitability of services. The agreement of customers to make product data available is crucial and is realistically only possible because it is part of the product-service offering.
- The transition can be regarded as a move from products to services, since the revenue comes from the service operations. It appears, however, that the sale of products has not reduced – in fact product sales are higher than previously – and that products are still central to the company's offerings. The transition can also be seen as a move downstream to take over activities from customers – product management and maintenance.

6.3 How are the products at the core of a product-service offering designed?

Having discussed the importance of products to the company's product-service offerings, this section explores how these products are designed. Interviewees involved in various stages of the company's NPI processes revealed their understandings of these processes. The focus of the interviews was on the early stages of the product lifecycle, until the point of certification which should rapidly be followed by production ramp up.

Product lifecycle

Aero engines are products with a relatively long life in service, for example there are engines currently in use which were designed in the middle of the twentieth century or earlier. Indeed Aero-Engine Co. does maintain engines which have not been produced for many years. Today, the lifecycle of an engine is seen as beginning with a formal request from a customer and ending when the company withdraws support for a model which has become rare enough to be part of the strangers and aliens category. It should be highlighted at this point, that the word customer differs in meaning. In the previous section, the word customer was used to describe airlines, or operators of an engine. In terms of product development, the customer is normally the manufacturer of an airframe, which will be powered by the model of engine under development. A simplified representation of the NPI process is shown in figure 6.1, which highlights some key milestones in the process.

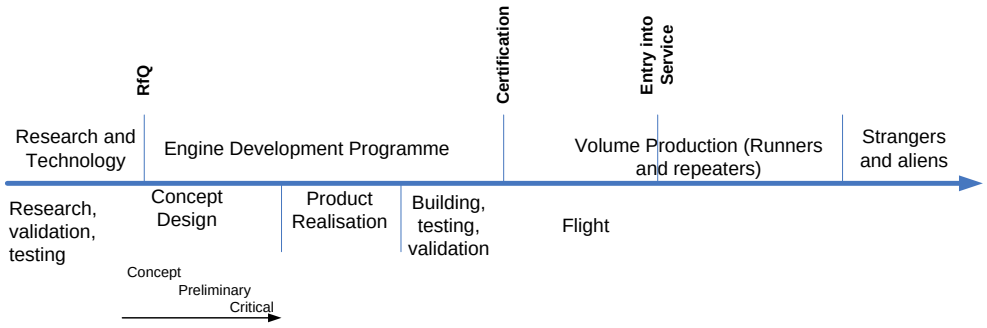


figure 6.1 – A simplified representation of the lifecycle of an aero-engine

The process formally begins with a request for a proposal (RfQ) from an air-framer, after which an Engine Development Programme (EDP) commences. The RfQ gives a set of specifications, relating to aspects such as the required weight, thrust and fuel burn of the engine and the characteristics of the aircraft it should power, such as the distance it is intended to fly and the expected weight and size. Based

on what capabilities are available in the company, in terms of existing technology and what can feasibly be developed in the required development time, a proposal can be made. Once this is agreed with the customer, the EDP is launched (Chief Engineer, R&T, April 2009).The EDP is generally preceded by some development activities which prepare the ground for a response to the customer's request. It proceeds through several design stages and levels of testing until a certification programme can be conducted and, once the necessary certification is achieved, flight testing and then production ramp up should commence. The entry into service sees the beginning of the engine's active life, at which point several airlines should be operating versions of the engine. The life in service of an engine should be several decades, during which time overhauls at regular intervals maintain its value as an asset, until the point when it is no longer supported.

Technology development

Prior to the commencement of an EDP, the company analyses both market trends and technology trajectories. Manufacturing processes, advanced materials and other technologies are developed strategically to meet predicted future market and product requirements. The company carries out basic research and technology development. This is often in conjunction with external partners and benefiting from government funding to establish research facilities. Additionally, collaborations with Universities and research institutes, such as Fraunhofer in Germany, are seen as an important way of preparing components, materials and manufacturing methods for the next generations of engines (Chief Engineer, R&T, April 2009). Collaborative research projects can develop elements which the company then seeks to integrate and put together for further development into commercial applications.

One interviewee (Executive, Supply Chain, May 2009) described a 'hopper' to collect concepts and ideas, which are then developed and subjected to testing before they can be utilised in products. Some view the company as being risk averse because, in theory, no new technology is used in new products unless it has been previously used or at least thoroughly tested (Supply Chain Manager, SCU 2, April 2009). A typical example was given of a component, which fulfilled the same function as an existing component, but offered a greatly reduced assembly cost over its predecessor. The component was subjected to around 30 different proving processes to ensure its reliability before it could be used. Where possible, new technologies are developed and tested independently of NPI projects, to ensure they are ready to be used in projects. This makes sense when the safety requirements and lengthy certification process are considered, since it would be inefficient to certify new technology concurrently with new products.

Conversely, one interviewee complained of a lack of technology development to produce 'off the shelf' technology (Supply Chain Manager, SCU 5, April 2010). While he recognised that testing outside of an EDP allows technology to be 'de-risked' and prepared for use in the next engine, he considered this to be lacking in his area of the business and illustrative of his view that engineers do too much design, when they should learn "when to put the pencils down".

Concept Design

Following an RfQ, there is "an awful lot" of design work required to reach a position where a basic concept can be presented (Executive, Supply Chain, May 2009). The request will specify the performance requirements of an engine for an aircraft under development. This will include the distance the aircraft should travel and its planned weight and size and the engine thrust required to power it (Chief Engineer, R&T, April 2009). It will also specify targets for such factors as emissions, noise and fuel consumption, including requirements set by aviation authorities, such as levels of Nitrous Oxide (Supply Chain Manager, SCU 5, April 2010). The technology which the company has been developing is used as the basis for conceptual design, normally the responsibility of an advanced propulsion team. This team, consisting of senior engineers with considerable previous experience, considers new products and 'tunes' engine concepts, asking questions like "what if I made it hotter? What if I made it shorter?" (Group Leader, Testing, April 2009).

An iterative process commences, with a detailed concept being designed and assessed at each iteration, by a group of senior engineers who have held positions such as chief design engineer or head of a subsystem on previous development projects (Chief Engineer, R&T, April 2009). They ask challenging questions about the maturity of technology in the concept, the stability of the supply chain for materials and the overall costs. After several iterations, a proposal can be made to the air-framer and must compete with proposals from rival engine producers. Normally no single proposal will meet all of the criteria set by the air-framer, so further iterations may be demanded, before a proposal is accepted. At this stage, the company seeks to convince an air-framer of their capability to develop an engine over the two to three years of an EDP, which will power an aircraft which is being developed. If this is successful, the air-framer

> *"will say 'I'm going to design the aeroplane with your engines'. Then you would launch an Engine Development Programme (EDP)"*
>
> (Chief Engineer, R&T, April 2009)

Engine Development Programme

The initial concept for a new engine is developed by a project team, once the EDP commences. At this stage, a plan of the whole engine is created to allow work to be broken down and divided among teams which develop sub systems, modules and components. This plan is "along the lines of a PERT diagram from the start of a major engine to the end" (Executive, Supply Chain, May 2009) which is incredibly complex "…if you tried to do that in any detail, you would die". The concept has been worked out at a high level, and the feasibility of developing the engine has been approved. At this point, "they've worked out that the stress is physically possible but there are lots of unknowns still" (Group Leader, Testing, April 2009).

In theory, the family of engines which the company has been producing since the 1990s are all designed according to a standard product architecture. The aim is to develop a gold standard, with the architecture and most of the components kept the same and scaled up to avoid 'surprises' in production (Supply Chain Manager, SCU 2, April 2009). In practice, however, the requirements of the market and the aviation authorities mean new technology and enhanced product design is required to make 'a step change' (Supply Chain Manager, SCU 5, April 2010) from previous models and meet increasingly stringent requirements. An EDP therefore involves developing a set of new components for the new engine, which are based on previous designs where possible. The development of these components involves a considerable amount of analysis, conducted by highly specialised engineers, for example, one interviewee gave an indication of the number of people involved in designing a typical turbine blade.

> *"There are 3, 4, 5 designers, there are the stress specialists, the material guys that look after the technology. You have to get the air system designers in there. There are 50, 60, 70 people working on this and all of them are using some models that have been put together by an advanced design group with lots of specialists and all this stuff. Its basically the work of a few hundred people…"*
>
> (Purchasing Executive, NPD, April 2009)

The term 'designer' is understood differently in different contexts, as chapter four should show. Due to the nature of the products and their complexity, in this context, a design team consists of highly specialised individuals responsible for analysing products from a particular technical perspective. Documentation to describe decisions made in the design process allows decisions to be examined by the appropriate specialists, whose analyses are taken into account when finalising the design.

> *"…that will go to a stress engineer, it might have to go to an air systems person, a thermals person, performance, aerodynamics, in the build area, config, fire and ventilation. And they will all send back a comment and its either ok or I don't like this..."*
>
> (Executive, Design, April 2009)

The design process then proceeds through a number of stages – conceptual, preliminary, critical – each of which is followed by a detailed design review, lasting several days and involving experts from across the organisation. The reviews concern technical aspects of the design and require a considerable level of detailed analysis, even at an early stage.

In addition to the engineering design of the product, the project team is expected to develop a detailed business plan. This means they consider 'technical' and 'non-technical' aspects at every stage. These terms are used to describe the engineering attributes of products and the logistical aspects of delivery. Within the company, therefore, operations such as supply chain management and production planning are referred to as non-technical.

A gated process is used to address all of the key aspects of the product design, with reviews lasting several days for each gate, to ensure the quality of the design and that all of the critical considerations have been addressed. In the past, the designs at this stage could be relatively uncertain and many questions would have been unanswerable (Executive, Design, April 2009). Now, the availability of previous project experience and the use of virtual modelling tools means this is no longer the case. The reviews gates involve a series of questions that "collect together the experiences of all of our ancestors" (Executive, Supply Chain, May 2009). In the distant past, development involved building a bigger engine and running it until destruction then examining what went wrong and building a new one (Executive, Design, April 2009). This was possible because a new engine could be produced in a matter of weeks and because there was no alternative at the time. At present, casting the engine casing would take too long and the engine would cost too much for this to be a feasible option. Additionally, there is a wealth of knowledge stored in databases and design models which enables far more sophisticated analyses. Virtual testing is used to carry out tests which "you would never actually do on the test bed anyway" (Executive, Design, April 2009) and which enable confidence in the design at each review gate.

Non-technical design

Review gates throughout the NPI process normally include both technical and non-technical considerations (Executive, Supply Chain, May 2009). For example, at a review gate, the technical feasibility of a component, its ability to fulfil safety requirements, the plan for manufacturing a required volume at an acceptable price and safeguarding supplies if suppliers cannot meet requirements, may all be assessed. Review gates are used to identify issues, such as design problems, which are then subject to a related process and require further development. Once reviews are passed, however, the team are

authorised to proceed with what has been presented and further funding is approved. The budget for the project "gets flowed down through review processes" (Executive, Supply Chain, May 2009).

Once a technical decision has been made, for example that a new type of fan blade is required, a decision must then be made on whether these blades will be produced internally or externally. This sourcing decision will be made according to considerations including maintaining competition between suppliers, and disaster recovery (Executive, Supply Chain, May 2009). For example, if an accident or disruption affects one supplier, alternatives must be possible to maintain production. Often these decisions are more heavily weighted towards the commercial than technical considerations (Manager, SCU 2, April 2009). In general, parts are manufactured in-house if they are considered to be 'critical or complex'. These parts may be vital to the functioning of the product and therefore making them in-house allows control over the quality of these parts. This is important for parts where tolerances and surface finishes can define the success of the product (Supply Chain Manager, SCU 2, April 2009). The safety of the product may depend on the quality of these parts and, since the company will be responsible for the consequences of safety issues, it makes sense to concentrate resources on making these parts, as opposed to others which are less critical. Non-critical components are those whose failure may cause a loss of power, but "nothing breaks, nothing fails, nothing kills anyone" (Manufacturing Manager, SCU 3, April 2009). Conversely critical components are ones which would cause major problems, for example resulting in parts being ejected from within the casing at high speed.

Certification

A significant factor affecting the development of products for civil aerospace markets is the requirement for certification. Due to the stringent safety requirements when flying passenger aircraft, all products and technologies are subjected to rigorous certification processes. These demand resources and planning in the NPI process, flight tests with newly developed aircraft, the testing of new technologies and often ongoing certification of new models and variants of engines. There are two major aviation authorities, one American, one European, and smaller bodies in other countries, for example China. Normally, once one of these bodies has approved the certification of an engine, then it will be accepted by the others, or at least reduce the certification requirements for the other bodies to approve it (Chief Engineer, R&T, April 2009).

Achieving certification requires the finished product to be put through a programme of tests, including destructive testing, which makes it necessary to build several engines. This requires the involvement of

suppliers in some capacity during production. It also means that supply chain management is required during development, as opposed to being scheduled after the product has been designed. The testing and certification requirements are a major part of the project and are therefore considered along with the design. In fact the design of testing rigs and the planning of a programme can be considered as major design activities and the design involved in planning a programme of tests represents a significant technical design effort (Executive, Supply Chain, May 2009). The stringent certification requirements, along with the ever shortening development times, contribute to a conservative attitude since it is preferable to utilise existing designs for components than introduce changes.

Post-certification

In theory, the product design should be complete after certification, after which a standard platform has been developed and tested. Once this milestone has been reached and following flight tests, to validate the engine's performance in the intended aircraft, any further modifications to the design are undesirable. This is because any modifications made to the design demand further testing and validation. This was compared to a box that has been closed

> *"If you want to open it, every time you change something you have to validate that modification against all the certification criteria."*
>
> (Chief Engineer, R&T, April 2009)

If the authorities require further testing, then it may be necessary to build another engine specifically for the purpose of certifying the modifications. In practice, the ever decreasing time limits on development mean that expensive modifications are often required after certification. On average, it is estimated that around 85% of design on most projects is completed by certification (Chief Engineer, R&T, April 2009). Further design work is often required prior to ramping up production. Additionally, once production commences, it normally takes some time before it runs smoothly and at ideal efficiency (Executive, Supply Chain, April 2009). There are, therefore likely to be modifications to the manufacturing processes and supply chain design at these stages. Finally, the continual improvement of technology and the identification of problems or errors mean that designs are updated during the lifetime of a product. In an ideal world, after certification, the design would be frozen, "that would be it for 30 years, 50 years" (Executive, Supply Chain, May 2009). In reality, modifications can seek to improve the design over the service lifetime, to make it cheaper to maintain or more efficient to run (Executive, Marketing, April 2010). In some cases, additional design effort may become a necessity if issues arise when the engines enter service and must be mitigated (Logistics Manager, R&O, April 2009).

Customisation

Certification has been described as a kind of cut-off point, after which development is complete and production can commence. If certification and flight testing are completed without problems and airworthiness is achieved, then the development is complete from the air-framer's perspective. For airlines, however, this is the point when a product becomes available for purchase. The certification, from their perspective is a sign that the engine works, but the airline may require modifications to be made to the standard model (Executive, Design, April 2009). This may be a request for the weight to be reduced or, in extreme cases such as engines used to fly over sea water, may involve a re-assessment of materials and coatings (Head of Programme Management, April 2009). Airlines make different demands on their engines, for example they may fly in wet or dry conditions; they may favour steep or shallow ascents. This means that products require customised design to meet these specific requirements (Executive, Supply Chain, November 2008).

During the EDP the company begins to make contact with airlines, through trade shows for example, to begin offering the engine which is under development. At this stage, the airframe is still under development, as is the engine, and both are likely to be a number of years from certification. Confidence in the technology, processes and personnel in the company enables them to assume that the development will be successful and they can deliver an engine to the airlines. This allows them to make long term agreements with customers, to deliver services for products which do not yet exist, with the conviction that they will achieve a solution and the output will be reliable. As one interviewee succinctly described it

> *"We don't sell products, we sell the promise of a solution"*
>
> (Executive, Supply Chain, November 2008)

Variations in engines are commonplace, meaning that the EDP produces a platform, from which customised products can be designed. A comparison was made by interviewees between variants of an aero-engine and variants in the automotive industry. One interviewee argued that it is possible for an auto engine to be standardised but used in different vehicles, with the same parts and slightly different electronics and fuel injection (Executive, SCU 4, April 2009). For example, the same engine could be used in a 3.5 litre and 2.5 litre car, reducing the cost of producing different engines. The interviewee considered this to be impossible for aero-engines due to the importance of weight. Slight differences in the usage by different airlines, for example how much energy they require in the cabin, as well as the take-off and landing styles make the precise specifications different and the design of the engine is

optimised as far as possible for the specific requirements. This results in several different variants of the same engine.

> *"Every aeroplane requires a modified engine, you cant buy a product off the shelf and we are talking about, if a programme is really working well, the biggest programmes are 5000 or 6000 engines and the first engine and the last one look different."*
>
> (Group Leader, Testing, April 2009)

Findings

- Products are developed in two stages. First an engine is developed to meet the requirements of an air-framer and achieve certification. Secondly, the engines may be modified and customised to meet the requirements of airlines which will operate the engine.
- The requirements of air-framers and airlines differ and may be in conflict, for example innovative technology and reliable operation. This means that one product is designed to satisfy two different customers and to meet both product and service requirements.
- Technical and non-technical aspects are considered simultaneously. While the engineering aspects are the main focus and those who design them are given the highest status, some non-technical design activities have grown in importance and begun to be more formal, bringing them closer to the technical design activities.

6.4 How is the organisation which delivers product-service offerings structured?

The company is divided into a number of businesses, of which the civil aerospace business is of interest, since it is the largest and also the one most suited to studying a product-service transition. Of the other businesses, defence is understandably more difficult to gain access to, while the marine and energy businesses rely on product sales, rather than services, for the majority of their revenue[2]. The company uses a complex matrix structure, in which employees belong to business functions, such as engineering, finance, marketing and so on but work together in projects and teams. In this case study, the focus is on the NPI process, as described in the previous section and the parts of the organisation which design, develop, produce, deliver and maintain product-service offerings. These parts of the organisation have been subject to recent restructuring, which is partly due to the increasing size and associated internationalisation of its customers and suppliers. It is also partly due to strategic decisions regarding forecasts of future market conditions, supplier development and manufacturing and staffing requirements (Executive, Supply Chain, April 2009). Four parts of the organisation are of interest here and will be described in more detail. These are the parts of the organisation responsible for interaction with customers, suppliers and integration between functions in the design of products. Firstly, the Customer Facing Business Units (CFBU), which are the sole point of contact for customers throughout product development and service delivery. Secondly, the Supply Chain Units (SCU) which are responsible for development and production of engine sub-systems. Additionally, the project teams and Integrated Project Teams (IPT) which are responsible for managing the development of new products are described here.

Customer Facing Business Units

In the literature reviewed in chapter 5, there is often an assumption, either explicit or implicit, that everyone in the organisation, and even in the supply chain, is required to be focused on the needs of the customer. It is perhaps surprising, therefore, to find that very few people in Aero-Engine Co. has any

[2] Data obtained from the company's latest annual report shows product and service revenue in each division over the last 5 years.

direct interaction with customers. In fact, when asked about "the customer", they would consider the requirements of the internal customers in the project they work on and its managers (Supply Chain Manager, SCU 5, April 2010) rather than anyone outside of the organisation. This is because the company has introduced CFBUs, which act as a single point of contact for customers and as a liaison with the rest of the company. During product development, a CFBU dedicated to the air-framer will deal with all of the communications. When any requests are made by the air-framer, the CFBU generates a business requirements document to convey instructions to the appropriate part of the organisation (Executive, Supply Chain, April 2009). Similarly, if an airline wishes to order new products, make changes to products in development or report issues with its existing fleet, it will communicate with the relevant CFBU. Requirements are cascaded down through the organisation, with responses passed upwards once actions have been taken (Executive, Supply Chain, May 2009). This requires that the customer facing unit includes technical and commercial staff, to communicate with the appropriate parts of the organisation. A simplified representation of the customer facing unit responsible for airline customers is shown in figure 6.2.

Within this CFBU are sales and marketing departments, which deal with initial contacts and commercial teams which negotiate agreements with customers. There are also several technical teams, which deal with the service delivery, for example the condition monitoring services offered as part of the company's product-service offerings. They also liaise with the technical functions within the company, to co-ordinate product development, introduction, maintenance and other services offered. The engineering organisation is often "pretty agnostic" (Executive, Marketing, April 2010) towards services, i.e. they are indifferent towards the ultimate use of the components or products they design, source and manufacture. The customer facing units are responsible for answering customer requests and accessing the resources inside the organisation to deliver what customers have requested. This means that "the voice of customer always comes through the CFBU" (Executive, Marketing, April 2010) while other parts of the organisation are responsible for delivering on customer requests. Occasionally engineers from outside of the CFBU may be invited to attend customer focus groups, but this is generally quite rare (Executive, Marketing, April 2010). One interview reported that technical experts are sometimes "wheeled out" to impress customers of the company's capabilities during negotiations (Executive, Supply Chain, November 2008), but otherwise allowed to focus on their technical specialties.

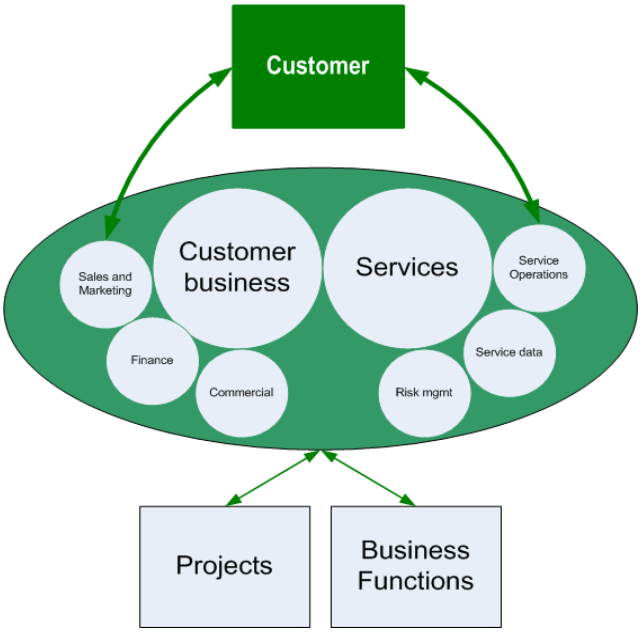


figure 6.2 – CFBUs provide a link between customers and the design process

The CFBUs have been involved in various exercises to enhance their staff's ability to be customer focused (Executive, Marketing, April 2010). For example, role playing exercises, forcing the different functional groups within the customer facing units to deal with a 'customer' have been utilised. This is part of an effort to alter the organisational culture in the CFBUs, which is seen as an important part of the product-service transition. Although there are plans to implement similar training exercises throughout the company, to date there has not been a widespread roll out. Instead there is an 'overlap' between engineers in the CFBU and in the rest of the organisation.

In effect, the CFBU acts as a kind of "buffer" (Supply Chain Manager, SCU 5, April 2010) between the customer-focused and the product-focused parts of the organisation. Reducing communication, so that customers communicate with the most appropriate people in the CFBU means that those responsible for product development and production can focus on their jobs with less distraction. This was reported as being an advantage, in the product-focused areas, since it removes the difficulties which dealing with customers can bring. For example, one interviewee, responsible for manufacturing components, welcomed the ability to schedule production according to a consolidated demand, with no distinction between product and service customers (Supply Chain Manager, SCU 2, April 2009). The alternative would be priority given to certain customers, because of the type of agreement their products are on or because the company wants to 'make them feel valued'. He argued that direct interaction with customers would lead to 'tampering' with schedules and make managing production more difficult. Another interviewee, whose role concerns managing R&O, reported that while it may seem better to be directly

involved with customers, the CFBUs have a difficult responsibility on 'the front line' (Logistics Manager, R&O, April 2009). They must manage customer expectations, and offer explanations when the company is unable to deliver to these expectations. In short, the CFBU helps to protect the product-focused parts of the business from customers, so that services can be delivered, without adversely affecting operations.

The growth of the company's product-service offerings and the organisation to support it was described by one interviewee as being internally driven and organic (Executive, Marketing, April 2010) in the sense that capabilities have been developed and offered to (airline) customers, "as opposed to doing real customer requirements, customer capture research". Product design is guided by the RfQ from an air-framer and then products are customised to suit individual airlines as appropriate. The interviewee found this unusual, since he argued that the relationship with customers should be "the fountain of all knowledge", which is consistent with the idea that product-service offerings should begin with an understanding of customers. The time pressures, 'fire-fighting' and other considerations have meant that the product-service offerings have evolved, with focus groups and workshops used to improve them. A planned research activity was reported, which should involve asking a broad group of existing and potential airline customers for their feedback on what they want from services and how they see the future of their businesses. Unconsciously echoing the integrated solutions literature, the research plan is to ask "what does their business look like, where can we help?" (Executive, Marketing, April 2010).

Supply Chain Units

While the CFBU can be regarded as the front office, the SCUs are effectively the product focused back-office. As with customer communication and CFBUs, all interaction with suppliers goes through dedicated SCUs. These are organised around the sub-systems of the engine, for example rotatives, compressors or installations and controls. They are responsible for designing, producing and assembling these sub-systems. This also means they 'own' the manufacturing supply chain for the sub-system, so that a SCU manages the set of suppliers or manufacturing facilities which produce their components. The SCUs contain staff from across the company's business functions, including technical experts to design components and manufacturing processes. This was described as a benefit since the people responsible for design, manufacture and sourcing of a component are co-located, removing barriers between them (Manufacturing Manager, SCU 2, April 2009). A component is designed by someone "upstairs" so the manufacturing engineers cannot blame problems on another function. The objectives, roles and bonuses of staff are also more closely aligned than they would be if they were in different functions.

The SCUs therefore bring different functions together, to take responsibility for products. In some instances, however, the company has, for strategic reasons, not retained capabilities related to particular components. Approximately 80% of manufacturing is outsourced, but design capabilities have also been outsourced in some of the SCUs. This is particularly notable in the installations and controls SCU, where the vast majority of components are outsourced. Electronic controls, for example are both developed and produced by suppliers, often making use of risk and revenue sharing partnerships (Supply Chain Manager, SCU 5, April 2010). Often there are very limited sources for certain components, meaning the supplier can dictate the price. Early involvement of suppliers in design can enable them to "drive the solution around something bespoke to them" (Supply Chain Manager, SCU 1, April 2009). This may be a necessary risk if the company considers it preferable to the cost of maintaining the required design capabilities. Suppliers have had a greater involvement in product development in the last "5 to 7 years" (Supply Chain Manager, SCU 1, April 2009) but a balance is struck between the benefits of early involvement and the risks of sharing intellectual property.

Each SCU has different relationships and strategic approaches to managing their supply chain. In one of these units, almost all production is carried out in-house, in a new and purpose built factory (Supply Chain Manager, SCU 2, April 2009). This means the supply chain unit deals with the design of components and the manufacturing operations for the critical and complex components they are responsible for. In another SCU, all components are produced externally, but some are designed internally, while others are completely out-sourced (Supply Chain Manager, SCU 5, April 2010). This unit is responsible for a range of different components. For very simple components, a unit cost is agreed with suppliers who deliver according to a fixed specification. Other components are very technologically advanced and require development by specialised companies, often through risk and revenue sharing partnerships. Low complexity components are designed in-house and their production contracted to a supplier, typically for a five year Long Term Agreement (LTA), with the supplier often selected on the basis of cost. Other components may be designed and produced by suppliers according to a spec known as a Component Requirements Document, with the design process assessed through review gates. Where suppliers are involved in design, they would typically have an on-site rep, based within an Aero-Engine Co. SCU, to act as a liaison with other organisations involved in product development.

Communication with suppliers or in-house manufacturing facilities is restricted to the appropriate SCU, meaning any requests to suppliers must be processed by them. This structure is in place to improve the

relationships with and efficiency of collaboration between the company and its supplier base. It means a single point of contact for suppliers in the company, or a clear "line of sight" (Executive, Supply Chain, , May 2009). This was described as "bringing complexity in-house" (Supply Chain Manager, SCU 5, April 2010). Different projects or teams in the company may require parts from the same supplier and previously this could mean the supplier having multiple contacts demanding their orders be given priority. Instead the SCU is responsible for prioritising and scheduling orders, so that, in theory at least, suppliers should enjoy more clarity and less complex communications.

Project team

The first stage of design in an NPI project involves a project team, consisting of senior individuals such as a chief engineer and chief design engineer, who are responsible for leading the overall product design. An example of a project team is shown in figure 6.3, reporting to a project director and combining expertise from the main functional areas across the company, with the main emphasis on engineering design. It also interacts with the CFBUs, which convey information from the customer and the SCUs, which design and develop components in greater detail. The project team rely on their own knowledge and experience, having worked on previous NPI projects to qualify them for their present roles. They also interact with specialists within SCUs to inform the decisions they make, for example directing questions towards aerodynamics specialists in the compressors SCU. This small team is responsible for the concept design of a new product, at a high level and with a broad scope. They consider the overall structure of the engine, for example how many compressor stages (Chief Engineer, R&T, April 2009). This would affect the weight, cost and risk, so such factors must be considered carefully to 'fix' the concept.

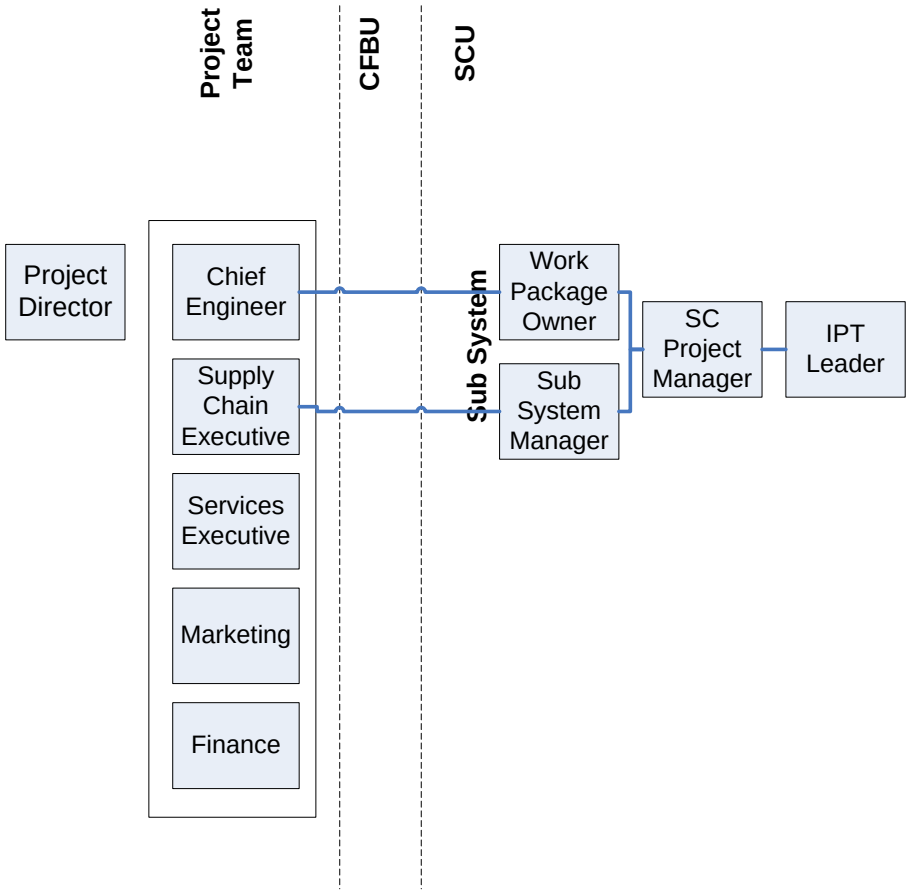


figure 6.3 – The project team reports to a Project Director and manages component IPTs

Component Integrated Project Team (IPT)

At the beginning of the EDP, the project team is very small but, as suggested by figure 6.4, more staff become involved later on. Once the high level design has passed the appropriate review gate, the engine is divided into modules, for example fans, shafts and turbines. Designing these modules for the new product becomes the responsibility of the relevant SCU (Executive, Supply Chain, April 2009). The project team 'owns' the resources to co-ordinate teams, but these teams are formed and populated within the SCUs, to design components and their supply chains or manufacturing processes, so that the SCU can eventually manage their production.

The SCUs form component IPTs for every component they are responsible for delivering. An IPT leader is appointed to each team, reporting to both technical and non-technical managers, as shown in figure 6.5. As described previously, review gates throughout NPI assess both the technical feasibility and commercial viability of anything which is developed. To ensure both aspects are given close attention, there is a close link between the Work Package Owner (WPO), who oversees the engineering design and the Sub System Manager (SSM), who deals with the supply chain and production issues. The close

relationship between these two roles leads to them being referred to as a "marriage" (Executive, Supply Chain, May 2009) when they manage an IPT. It is considered necessary to have such close connections between individuals with different specialisations and this occurs within the IPT itself. The IPT brings together design engineers and manufacturing engineers who, by working together, provide knowledge and experience which few individuals can possess alone.

> *"…you need practical experience and engineering genius, but you cannot combine it within one person, there are very few. So you need to split it up. Perfect engineer and perfect manufacturing engineer."*
>
> (Manufacturing Engineer, Design, April 2009)

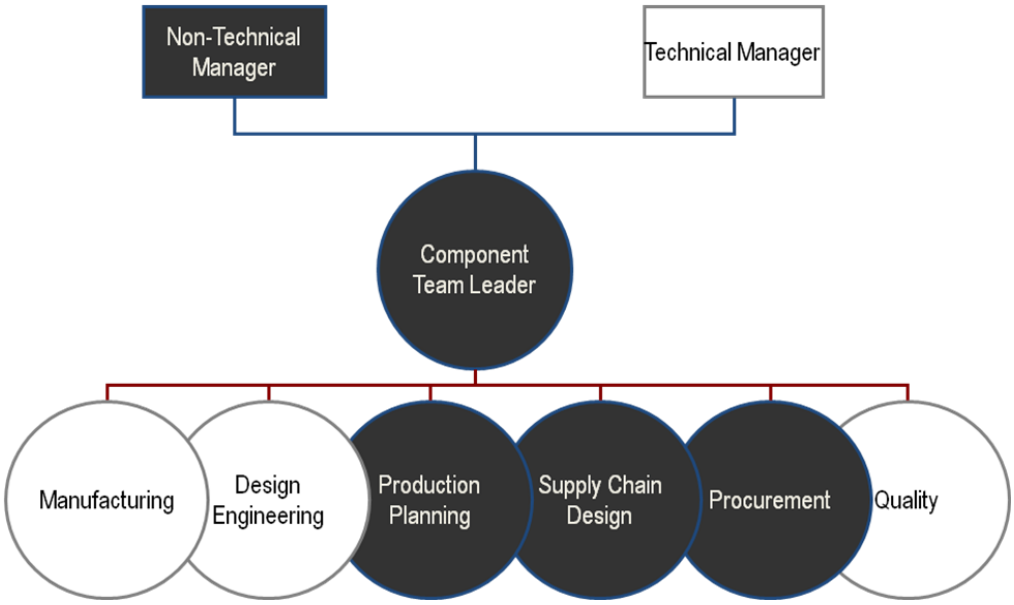


figure 6.4 – integrated teams combine the specialisations required for the design task

The specialisations shown in figure 6.5 are an example, showing how a typical component IPT might look. The diagram shows technical and non-technical specialists, and the technical (WPO) and non-technical (SSM) managers who the IPT leader reports to. The precise make-up of an IPT varies according to the component they are required to develop, the technical specialisations required to develop it and the SCU's strategy for producing or purchasing the component. Where the IPT is developing a critical component, to be produced in-house, for example a shaft, the team may be composed mostly of manufacturing engineers and production planners. This type of component will perhaps not require much supplier involvement and relies more on design features than novel technology (Manufacturing Manager, SCU 2, April 2009). Additionally, the manufacturing engineers will have an influence on the product design since it must fit the layout of their factories. In other IPTs, suppliers may be involved in the team, since they will have more responsibility for producing and, potentially, designing the component. Where a supplier is given responsibility for product design, they are provided with a

Component Requirements Document, which represents the specification they must deliver to. This specifies an 'envelope', for the dimensions the component must fit within and the temperature, vibration, flow rates etc. The supplier must develop an appropriate solution which meets all of the technical requirements and fits within the envelope. Although they have freedom over the design, they are governed by a gated process similar to the company's own designers. In fact, it has been suggested that external design teams are more strictly controlled than in-house teams (Executive, Design, December 2008) to ensure the quality of their output. The suppliers normally have on-site representatives, who work with or within IPTs, to ensure that the component they design will be integrated with other components and meets the non-technical requirements for sourcing and production. They will typically be on-site for three years, to work on the entire development, and make the relationship with the supplier as smooth as possible (Supply Chain Manager, SCU 5, April 2010).

The IPT is formed at a certain point during an EDP, once the relevant review gates have been passed. It is in place until certification and testing have been completed, after which time its responsibility is considered to be complete. Production ramp-up takes place shortly after certification, at which point the responsibility lies with SCUs. The staff within the IPT then return to their functions and can be re-assigned to other projects. Working within IPTs, therefore, facilitates the transfer of knowledge throughout the company. There is uniformity in the structure and job roles across the organisation, at least in each site. There is also a vision of such uniformity across the company's global sites. It is expected that in future, globally distributed IPTs may become the norm, with team members being based in the UK, other parts of Europe, North America or beyond (Executive, Supply Chain, April 2009).

Findings

- Customer Facing Business Units (CFBU) have been created as an interface between the company and customers, they also act as a buffer between the product focused engineering personnel and the customers.
- Supply Chain Units (SCU) are used to manage supplier relations but also to deal with the complexities of component design and production, contributing to the integration of various functions and operating a strategy appropriate for the production and sourcing of their components.
- Integrated Project Teams (IPT) create temporary groups which enable concurrent design of technical and non-technical aspects of products. They also provide individuals with knowledge of other functions, which helps share knowledge through the company.

6.5 How is design used in a product-service organisation?

In chapter 4, definitions of design, from literature published over the last five decades, were explored. These definitions suggested differing and evolving understandings of design in different industries, companies, academic disciplines and between individuals within all of these. They also suggested confusion between designers and design (e.g. Perks et al., 2005b) and the common mistake of overlooking silent design (Gorb and Dumas, 1987). In this case study, each interviewee was invited to share their understanding of design and experience of design activities conducted by themselves and their colleagues. Seeking to capture silent design, interviewees came from a range of disciplines and backgrounds, offering an insight into the role of design in different SCUs, CFBUs, stages of product development and service delivery. They included not just those individuals whose job title contains the word 'design' but also those who manage design at various operational and strategic levels or whose jobs contribute to design in the company. This offers a more inclusive perspective than interviewing 'designers' would and is in line with the goal of identifying silent design.

The question of the role of design was addressed in two stages. Firstly, the definitions and descriptions offered by interviewees were used to consider what design means within the context of this company, with comparison to the working definition identified in chapter, based on Archer's (1965) prescriptions. Secondly, design activities identified from the interviewees were gathered and categorised. These activities were either reported by the interviewees explicitly in response to questions about design, or were extracted by the researcher from descriptions of operations in the interview transcripts. The frameworks which were developed as a result of the case studies described in chapter 4 and 5 were combined to analyse the activities and develop an overview of the role of design in developing product-service offerings in Aero-Engine Co.

What is design?

Due to its origins as a producer of high quality engineered products and historical reputation of technical excellence, the company's design activity is closely associated with its engineering functions. For this reason, several interviewees reported that design and engineering are treated as synonymous terms. Design in the company is normally considered in relation to specific marketable products (Executive, Supply Chain, May 2009) and is generally used to refer to the engineering activities involved in developing and producing these products. Those directly involved in engineering activities

understandably considered design in this sense. While they were helpful when asked to consider silent design activities, they politely pointed out that the categories of business-facing and customer-facing design were not what they would think of as design. As discussed earlier in this chapter, technical excellence is highly regarded in the company and engineers are afforded a higher status than other functions.

A distinction was made by several interviewees, between technical and non-technical design activities. The former refer to the design which occurs within the engineering department, such stress or aerodynamic analysis, component or tooling design and development of test rigs and equipment. The latter describe commercially focused activities such as supply chain design or production planning, which may be considered less glamorous by engineers, but are an important part of delivering profitable and reliable product-service offerings. During the interviews, similarities between the technical and non-technical design activities were identified by the interviewees. These were related to the cognitive functions or design tools used in the respective processes, rather than the outputs. When asked to consider what they regarded design to be, three themes could be observed: design as a creative process, design as modelling or simulation of planned outputs and design as integration.

Design as a creative process

One interviewee identified design as a cognitive process, resulting in a creative or novel output, in agreement with the definition proposed in chapter 4.

> *"I'm not a native English speaker, so what comes between design and technical design its a way of how to interpret stuff…to put it this way, its a creative work that you have to do. You have to use your brain, you have to think about something, set something up, design some ways of doing things."*
>
> (Chief Engineer, R&T, April 2009)

German, the interviewee's first language, distinguishes between industrial design and technical design, while one of the sources of confusion for English speakers is the use of the same word for both concepts (Mutlu and Er, 2003). Yet, putting aside the issue of interpretation, he specifies the requirements for creativity and novelty. The level of creativity involved can vary, but he argued that using the brain to create something new is a requirement of design. He regarded his own role as managing others who carried out creative work, but clearly did not see the management itself as creative enough to qualify as design. In these terms, processes resulting in different types of outputs can be classed as design activities, although he clearly feels only engineering product design deserves the name. Another interviewee focused on the requirement of utility in their understanding of design:

"…anyone creating new things that are tested to be fit for purpose is designing."

(Executive, Design, December 2008)

This appears deceptively broad, along the lines of 'everything is design' type definitions. On closer examination, however, the requirement for testing and being fit for purpose indicate that the new things which are created are done so deliberately. They are created *by design*, rather than by accident. They must also have some objectives or requirements whose fulfilment can be tested to measure the success of the design. This interviewee distinguished between two stages of design activities, proposing that all of the company's design activities can be separated into defining and verifying. Defining involves collecting information and specifying requirements, which are necessary steps in designing, while verifying, involving simulating or testing are also important. He considered, however, that the activities of most interest are somewhere between these, at the point where analysis ends and synthesis begins.

While analysis is a big part of a designer's role, whether it qualifies as a design activity was a source of much debate. Archer's (1965) definition of design stressed the requirement for a creative step as opposed to analysis, or calculations alone. Yet the standardisation of the design process, to shorten development times, increased use of virtual modelling to reduce costs and the pressure to minimise changes, to avoid extra certification work, have led some to see the designer's role differently.

> *"…the design job has significantly changed over time. You say today what's the difference between analysis and design? Now there's none."*
>
> (Executive, SCU 4, April 2009)

Years of product development have resulted in a library of models and tools to make the design process more efficient (Executive, Supply Chain, May 2009). The job of designers is often to programme these models with data from the project they are involved in, and interpret the results to help them specify components. Although there was a suggestion that this could be completely automated, in the foreseeable future the human mind, with its creative capacity is a necessary part of the process (Executive, Design, April 2009).

Design as modelling

It may be argued by some that an engineer, defining components according to the results of analysis and calculations is not truly designing. Yet, another way of viewing design activities is, again following Archer, a prescription or model, to be embodied in a finished work. Producing models is a major part of the design activity in the company, with virtual models equipping designers with knowledge that was previously unattainable. The virtual models enable testing which would be too costly to carry out

physically, for example assessing how variations in manufacturing tolerances or operating temperatures affect products (Executive, Design, April 2009). Extreme environments which would be difficult to recreate in reality can be simulated, enabling optimisation of products for operation in difficult environments and extreme conditions. This virtual modelling reduces the cost of testing and improves product design, to make the end result "more stable" (Executive, Design, April 2009).

Taking the viewpoint that modelling is a design activity and acknowledging that much of the designers' analysis in the company is related to virtual models of components, presents a different perspective. One interviewee considered that the advantage of CAD drawings, thermal models and other ways of visualising products in the design phase is to enable modifications "before you spend huge amounts of money" (Executive, Supply Chain, , May 2009). He drew parallels with simulations of supply chains, arguing that "there is a very clear equivalence". By this definition, anyone producing models and simulations in the company is carrying out a design activity. Analysis of the model and subsequent iterations and modifications, directed towards a particular aim, such as meeting weight, cost and strength requirements, could be regarded as design. Equally, modelling a supply chain, then analysing the costs and risks, modifying and iterating the model, can be considered to be design. These are the responsibility of supply chain designers, whose task is to design "the whole value stream from raw material out the ground to parts delivered [to the CFBU]" (Supply Chain Manager, SCU 5, April 2010).

The standard role of supply chain designer has been introduced recently, by identifying the activities involved in managing supply chains and seeking to formalise the implementation of these activities. This involves the training of people filling the role to "up-skill" them and enable them to contribute more effectively to product design (Executive, Supply Chain, May 2009). It also involves the development of modelling tools and processes to support the supply chain designers in making decisions at a senior level, to "try to give them more teeth". By bringing the working methods of non-technical designers closer to those of the technical designers in engineering, the aim seems to be to give them more credibility and therefore greater voice. The use of modelling tools appears to be a big part of this. One reason why modelling is invaluable to designers is that it helps them manage the conflicting requirements of products, for example weight and thrust. Supply chain design also involves trade-offs, for example unit cost and transportation costs, or reliability of the supplier. Using models can help a supply chain designer to consider and optimise all of the relevant factors in a complex system, integrating many different elements.

Design as integration

An important part of the company's design process is the integration of many parts in an incredibly complex structure to deliver a coherent output which meets all necessary requirements. In terms of product design, the complexity of an aero-engine is greater than perhaps any other product on earth, so integrating all of the components and meeting overall requirements is a staggering task. No single individual would be capable of managing the technical integration, so the task is broken down as described earlier in this chapter. When discussing the role of designers in the company today, integration was considered by some interviewees to be the major responsibility.

> *"The designer is the middle. If you have the designer of a part and you have, for example, all the analysts supporting the designer, so it's more an integration task and also [they are responsible for] the integration with manufacturing."*
>
> (Executive, SCU 4, April 2009)

This interviewee considered that design involves making sense of the recommendations or analyses of various experts and developing products which satisfy these different perspectives as far as possible. He also added, almost as an after-thought, that integrating the product's performance requirements and the manufacturing processes to create them is an important part of design in the company. Returning to the concept of technical and non-technical design, the NPI process and organisational structure described in this chapter are clearly intended to facilitate the consideration and integration of both. Managing projects involves a great deal of integration effort, which some consider to be a design role.

> *"I would not underestimate the sheer effort that goes into keeping a whole programme integrated. That I think is part of the design."*
>
> (Executive, Supply Chain, May 2009)

Others felt that integration is a management activity and did not consider it to be a type of design (Executive, Supply Chain, May 2009). This was mainly because they considered the task of managing projects to be more administrative, "driving a common template" and ensuring those they manage are "sticking to generics". Clearly personal opinion influences whether these interviewees regarded integration as a design activity or not. Yet it was argued that, increasingly, the role of designers is integration. One interviewee commented that designers spend less time at drawing boards than they did in the past, to the point where a drawing board could not be located anywhere in his facility (built in the early 1990s) when one was required to modify drawings for an out of production part on a 'legacy' engine. He considered that they

> *"… they spend less and less time actually designing something, they are much more engaged in all these processes and integrating these processes because the designer is the integrator for all of the processes. "*
>
> (Executive, SCU 4, April 2009)

He seems to assign a great importance to the designer, as the integrator *for all of the processes,* yet does not seem to consider this integration as design. There is clearly some debate over the extent to which these integration tasks can be considered design activities. Yet it has been argued that the role of design in organisations is often that of integration between different functional departments (Rothwell, 1992). Design is also considered to be a bridge between the needs of customers and the organisation (Walsh, 1996). Meanwhile design thinking has been described in terms of the integration between analytic and intuitive thinking (Martin, 2009).

Defining Design

Following this discussion, the working definition of design can be revisited and amended:

> *"Design is a creative, mental process which results in a prescription or model, to be embodied in a finished work, it is not the finished work itself (the product of the process) nor is it the result of equations or selections alone".*
>
> (based on Archer, 1965)

The concept of a creative mental process was identified in interviews, as was the idea that creating models or prescriptions is a design activity. The restriction on equations and selections seemed less applicable in this context, where analysis is a crucial element of design. Finally, the concept of integration, whether of components in technical design or of the needs of various stakeholders emerged as relevant. Therefore a modified definition of design activities, to apply to this company is proposed:

> *Design is a mental process involving some degree of creativity rather than being fully automated. It results in prescriptions or models to test fitness for purpose or to be embodied in a finished work. It can also involve integration of disparate elements or conflicting requirements to achieve a satisfactory outcome.*

Design activities

Interviews were conducted with 23 individuals, whose experience spanned the whole of the product development process and various parts of the organisation. Each was asked about the design activities they and their colleagues are responsible for. From the interview transcripts, 44 activities were identified and listed in a table offering descriptions and direct quotations from the interviewees. These design activities were categorised in a number of stages, using the frameworks described in chapters 4 and 5 and building on the findings of this chapter. The design activities were assessed in four steps, as follows

1. Whether these qualify as design activities
2. What type of design activities they are
3. What stage of product-service development they fall under
4. Who the customer or stakeholder they benefit are

To assess the reliability of the categorisations, two independent researchers were invited to review the design activities and categorise them. The independent researchers considered themselves as experts in design and had previous exposure to both the researcher's work and the company. They were therefore considered to have sufficient knowledge and experience to enable their involvement. They had also signed non-disclosure agreements with the company and therefore data could be shared with them for the purpose of the analysis. The independent researchers categorised 11 (25%) of the activities, in a sequence of four steps and their agreement with the researcher's classification after each step was calculated. These 11 were selected randomly by the independent researchers, who were provided with a complete set of activities, printed on strips of paper. These are presented in table 6.1, while a full list is included in the appendix. From this point, the activities will be referred to by the initials and number in the "source" column.

The independent researchers discussed the design activities, asking for clarification of the context, where appropriate. At this point, some of the activities were highlighted in which the descriptions were particularly unclear or the quotations insufficient to make a judgement, these were reviewed later and improved. Each of the two independent researchers made their own judgement at each stage, after the discussion. Subsequently, the classification was re-evaluated by the researcher and agreement calculated again. The exercise lasted a total of 120 minutes, including the explanations and discussions. The available time restricted the number of design activities which could be reviewed.

Description	Evidence	Source
Producing some (non-critical or complex) components requires design to create a shape which offers the required physical properties.	*"There's more novel design features in [shafts, rather than novel technologies]. We have particularly thin sections that are designed to flex, so that's a design thing."*	CM (1)
Supply chain design is a design activity since it involves the creation of a plan for moving material between suppliers and factories.	*"we've got this new role called supply chain designer and the intent of that role is for us to design the supply chains from raw material out the ground... so the whole value stream from raw material out the ground to parts delivered...and then it would be up to the CFBU, the Customer Facing Business Unit, to manage the part from there."*	AT (2)
Specifying requirements with respect to product-service involves design to create an optimum configuration.	The requirements specified now need to be reviewed, for example the trade-off between the time between overhauls and the engine's fuel burn. A less efficient engine is acceptable if the cost to the company of reducing fuel efficiency is balanced by the saving on maintenance. Requirements require optimisation across the life time of the product, rather than performance in use alone.	DK (2)
Developing product-service offerings involves design to facilitate maintenance.	New products need to be designed for maintenance, which includes making components more accessible for repair and also can involve modularisation, to make it easier to replace individual components. The aim for new products is to make detection and repair of faults easier, faster and cheaper... Using a boroscope allows faults to be diagnosed without removing the engine from the wing of an aircraft, like conducting keyhole surgery on an engine. There are cost and time savings if repairs can also be conducted in situ.	KL (3)
Design for service workshops involve creating proposals for service related improvements to components and products.	*"...they were talking about some issues in the later stages where they haven't got enough holes on the casing to carry out a boroscope study on wing. At the product design stage, the design for service community should pick that up or they should make alternative arrangements for repairs at future shop visits. Not every time it is possible to get rid of these things. The emphasis is on reducing the weight at the moment."*	GS (1)
Manufacturing processes are designed to meet the optimal flow for the factory where production will occur.	*"we introduce a sealed method to the rest of the factory... how we make sure we're doing it ABCD is we have the template that says that's the way we make the part, we argue with design to make it fit that process and if there's exceptions, we flag it up that this part is going to have to go back through the factory and be inspected again, are we happy with that? Are we going to have to buy a new machine?*	CM (5)
The visual appearance of an assembly and test facility shows signs of design to create an environment which is suitable for customer.	The design of some new facilities shows consideration of customer perceptions. A plant producing parts for out of production engines has been unchanged for years. Meanwhile a new assembly and test facility is regarded as exceptionally clean and technologically advanced. Visitors are likely to be shown the latter.	KL (1)

Developing product-service offerings involves design to facilitate maintenance.	New products need to be designed for maintenance, which includes making components more accessible for repair and also can involve modularisation, to make it easier to replace individual components. The aim for new products is to make detection and repair of faults easier, faster and cheaper... Using a boroscope allows faults to be diagnosed without removing the engine from the wing of an aircraft, like conducting keyhole surgery on an engine. There are cost and time savings if repairs can also be conducted in situ.	KL (3)
Developing a product vision is a design activitiy since it involves the iterative creation of an overall plan for the product.	*"...there are a lot of decision meetings before you are starting with development...in this stage they are at first planning the purpose of what we want to achieve. Then you go through several aggregation steps during engineering drawing, safety issues and everything. And you go into this loop again and again and again to achieve what you have in this stage, your 'vision' of the product."*	NS (2)
Developing product-service offerings involves design	Where parts are required to be replaced less often, their lifetime should be extended. This can be achieved by altering tolerances or the materials used for components.	CJ (1)
Manufacturing processes and supply chains are re-designed following updates to product designs.	*"we work with the designers as the design evolves to design the method of manufacture, as the supply chain designers will then take that evolving design and design a supply chain which one day didn't have a coating supplier and the next day because the design has changed they have to change the supply chain to accommodate those kind of things."*	CM (4)

table 6.1 – The set of design activities reviewed by the independent researchers for the purpose of assessing reliability

Do these activities qualify as design?

The working definition of design described above was used as the basis for including the activity as a type of design. As discussed above, the list included activities which the interviewees themselves may not have classed as design. This was expected, since this exercise was used to find silent design activities, which would not necessarily be made explicit by the interviewees.

Of the sample of design activities, there was general agreement that the majority fit the definition of design and should be included in the analysis. There was one exception, with one of the two independent researchers arguing that CM (5) could not be considered to be design, since the interviewee describes a desire to follow a set procedure rather than to create something. The other independent researcher, however, agreed that the interviewee describes how he influences the design of a product, in this case using the inefficiency would result from the proposed design to argue for an alternative which better suits the layout of a factory. In a later re-evaluation, this activity was dropped by the researcher. Leaving aside this exception, the level of agreement at this stage was very high:

What type of design activities are these?

The classification developed in chapter 4 was used to categorise design activities reported by the interviewees as one of the following:

1. ***Customer facing design:*** *design of things which support communication and interaction with customers. These are normally visible to customers.*
2. ***Product design:*** *design of the core product or service which is sold to the customer.*
3. ***Business facing design:*** *design of things which support production and delivery of products and services. These are normally invisible to customers.*

At this point, more disagreements between the two independent researchers emerged. These were explained by the differences between the independent researchers in their familiarity with the categories. Since independent researcher 2 had more previous exposure to the categories of design, his categorisation of activities was closer to that of the researcher. The main point of contention was on the meaning of customer-facing design, which was intended to include mainly marketing, promotion and communication materials. Independent researcher 2 understood the categorisation in terms of *what* is being designed, while independent researcher 1 distinguished between *who* benefited from the design. This meant that, for example, GS(1), which refers to the re-design of components to enhance their life in service, was regarded as customer-facing since it benefits the customer using the product or as product design because it affects the product itself. This was seen as confirmation that the design of products can

be intended for different customers, as previously described in the investigation of the NPI process. Agreement with independent researcher 1 was low, while independent researcher 2 was relatively high at this stage.

What stage of product-service development are these activities used?

Using the model developed in chapter 5, the process of developing product-service offerings was considered to consist of three stages. The design activities were categorised as falling within one of these three stages.

1. ***Defining value:*** *understanding the needs of customers which should be satisfied by the solution and the technological and organisational capabilities of the company.*
2. ***Designing value:*** *developing solutions to meet customer requirements, in terms of the product and service delivery.*
3. ***Delivering value:*** *maintaining the customer's access to the benefits delivered by the solution*

This exercise revealed some differences with the independent researchers. The main difference was that design activities which the researcher had categorised as part of "defining" or "delivering" were classed as "designing" by the independent researchers. Clearly all of these activities should involve designing, but there was some disagreement over what was being designed. For example, NS2 was considered to involve defining value, since it relates to the development of a 'product vision'. The independent researchers both considered this to be designing value, but arguably the offering is not being designed at this stage, rather the product concept is being defined. As agreement between the two independent researchers was high, a re-evaluation was in order.

Who is the customer?

As describe earlier in this chapter, the company essentially meets the requirements of two types of customers, through the development of one product. The identified design activities, therefore, were classified as being aimed at one of the following:

1. ***Air-framer:*** *acting as an OEM to which Aero-Engine Co. is a supplier and product development partner. New engines are developed to meet the performance requirements of the air-framer's new aircraft, beginning with request for quotation and ending with flight tests when the engine and aircraft are certified.*
2. ***Airline:*** *acting as a service customer to which Aero-Engine Co. delivers services. The airline runs a fleet of aircraft for which it purchases engines (or the equivalent product-service offering).*

The independent researchers were asked to identify the customer for each of the design activities they were considering. They identified that some of the activities were clearly aimed at satisfying air-framers and others airlines. They also identified that an internal customer was the main beneficiary of some

activities. For example, AT(2) describes the design of supply chains, explicitly identifying the CFBU as the customer. Since this had not been considered by the researcher, agreement was initially very low.

The reliability of the researcher's coding was assessed using Cohen's κ, as recommended by Paroutis and Pettigrew (2007). The values for Cohen's κ were calculated at each step in the analysis, to assess the level of agreement between researchers and hence the reliability of the researcher's analysis. The results are shown in table 6.2. Miles and Huberman (1994) recommend the use of reliability checks such as this at an early stage in analysis. They found that agreement is normally relatively low initially, but improves when the analysis is re-evaluated.

	Agreement (Cohen's κ)			
	1 (design?)	2 (category?)	3 (stage?)	4 (customer?)
Agreement with independent researcher 1	0.91	0.40	0.60	0.50
Agreement with independent researcher 2	1.00	0.91	0.64	0.55
Agreement between independent researchers	0.91	0.40	1.00	0.70

table 6.2 – Reliability, measured using agreement with independent researchers.

Goffin and Koners (2011) also achieved initial inter-coder values of around 50% between two coders. They attributed this to a need for definitional clarity, which caused a higher than expected level of divergence between the coders. Following discussions to clarify the definitions, they were able to achieve values of around 80%.

Classification of design activities

Following the initial analysis and assessment of reliability, as described above, a second round of classification was carried out by the researcher. This took into account the discussions held with the independent researchers to clarify the analysis and attempt to minimise subjectivity. The final classification is presented in table 6.3, while more complete descriptions of the design activities can be found in the appendix.

	Developing offerings for Air-framers		
	DEFINING VALUE	DESIGNING VALUE	DELIVERING VALUE
CUSTOMER FACING DESIGN			
PRODUCT FACING DESIGN	Defining requirements for a new product; Specifying requirements with respect to total lifetime cost; Specifying system requirements	Developing product vision; Design of critical and complex components; Desiging components for longer life; Design of manufacturing methods; Developing designs to be used in future products; Technical design and analysis of components	
BUSINESS FACING DESIGN		Manufacturing processes; Tooling design; Modifications to production drawings; Design of testing equipment; Re-design of manufacturing and supply chain; Modelling supply chains; Supply chain design; Programme Management	
	Developing offerings for Airlines		
	DEFINING VALUE	DESIGNING VALUE	DELIVERING VALUE
CUSTOMER FACING DESIGN		Specification of packaging requirements; Designing repair and overhaul facilities for access to transportation links	Designing environments to impress visitors; Reports and training for customers, to improve usage; Scheduling shop visits for entire fleet
PRODUCT FACING DESIGN	Defining requirements for future products; Analysis of components	Customisation of standard engines to suit individual customers; Designing for ease of maintenance; Communication between design, manufacturing and supply chain personnel; Defining weighting of design factors	Re-design of components which do not meet expected lifetime in service; Designing new components for engines in service; Designing parts for out of production engines
BUSINESS FACING DESIGN		Designing transportation routes; Designing commodity strategy; Design of workplaces; Design of new manufacturing facilities; Re-design of existing manufacturing facilities	Design of new manufacturing facilities; Designing facilities for access to transportation links; Re-designing commodity strategy; Repair schedules

table 6.3 – A classification of the design activities described by interviewees

Discussion

The table above demonstrates the value of this research for both researchers and practitioners. By using the theoretical framework which has been developed, it is possible to analyse an incredibly complex topic in a particularly convoluted and messy context. The categorisation of design activities, stages of value creation and types of customers helps to give structure which is valuable for researching such contexts. For companies, which often do not explicitly recognise design activities of the kinds identified here, such a framework also offers clear benefits. The framework helps in identifying customers and the value created for each customer by design activities at each stage. Representing the design activities in this manner can help in identifying gaps as well as ensuring the activities are correctly aligned with the needs of the customers they are intended to create value for.

Clearly this is not a comprehensive list of all the design activities in the company, nor is it intended to be. The analysis provides an insight into the type of design activities in a product-service organisation. Predictably, the majority of the activities are clustered in the product design area, even though not all of the interviewees were directly involved in these activities. This is explained by the complexity of the products and the immense engineering design effort required. It is also to be expected since design is normally understood as technical product design, which represents the majority of effort in most companies (Livesey and Moultrie, 2009). In particular, the aerospace sector was found to be one of the most dependent on product design and development by Sentance and Clark (1997) in their survey of UK manufacturing companies. Despite Aero-Engine Co. being considered as a service company, the importance of product design appears as strong as ever. The day to day jobs of designers have evolved, and include more analysis and integration as described by some of the interviewees directly involved in product design. The role of product design, however, remains crucial in creating products and providing the basis for product-service offerings.

The business-facing design activities would also be expected to be high, if Sentance and Clark's (1997) findings still apply twenty years later. They found aerospace companies to be heavily involved in process and systems design, in comparison to other industry sectors. When examining the business-facing design activities reported, it is notable that most of the design is for components produced by suppliers, which has made supply chain design more important than in the past. Within some SCUs, such as rotatives, the design of manufacturing processes and production planning activities are important. This is the exception, however, since the majority of production has been outsourced. The importance of supply

chain design, to develop a network of partners was described in chapter 5. Processes and tools are being developed to enhance the capability of its supply chain designers, in recognition that this capability is crucial to the delivery of product-service offerings.

Finally, from Sentance and Clark's (1997) survey, customer-facing design effort, would be expected to be very low. They found that in the aerospace sector, spending on graphic and branding design was less than 1% of the total design spending. Although the category of customer-facing design is more comprehensive than graphics and branding, the interviews revealed some design effort which is clearly aimed at promoting the company or simply understanding customers' needs better. Most notable among these was the design of a factory which was reportedly aimed at creating a favourable impression for customers (Supply Chain Executive, November 2008). This suggests that even while engineering dominates the company, the customer experience (Pine and Gilmore, 1999, Zomerdijk and Voss, 2009, Beltagui et al., 2010a) has become more important. While the introduction of a service culture is arguably very limited in the company, it has made employees – in the CFBUs at least – more customer oriented and resulted in more customer facing design.

Design is clearly most important at the stage of 'designing value', yet it is clear that there are design activities involved in specifying requirements, modelling products and supply chains and other activities at the 'defining' stage. Additionally, the importance of R&O makes design activity increasingly important at the 'delivering' stage. The analysis of design activities made it clear that there are different customers, including CFBUs, Air-framers and Airlines. A single product may be designed to meet the needs of several customers, as identified earlier. For those responsible for designing the products and particularly those managing their production, the CFBU is regarded as the customer. When developing products for product-service offerings, it would be valuable to identify which customer the product will create value for. For some of the design activities, the independent researchers demonstrated some confusion over who the main beneficiary would be. This is an indication that clarifying who will gain value from the product, in order that their needs, as well as those of the company can be satisfied.

Findings

- Design can be defined as a mental process involving some degree of creativity rather than being fully automated. It results in prescriptions or models to test fitness for purpose or to be embodied in a finished work. It can also involve integration of disparate elements or conflicting requirements to achieve a satisfactory outcome.

- Design activities create value for different customers, so identifying the beneficiary and ensuring their needs are considered and satisfied is important.
- The role of design in a product-service organisation is dependent on the sector and the company history, but making a product-service transition requires more customer-facing design, since there will be closer interaction with customers, and business-facing design, to integrate the efforts of different partners.

6.6 Conclusion

This chapter has investigated the nature of the company's offerings, the structure of its organisation, its design process and the range of design activities carried out by its employees. It found that the design process involves two stages, resulting in the creation of value for two different classes of customers. Firstly, in its role as a supplier to air-framers, the company develops new products to power new aircraft. Secondly, in its role as provider of products and services to airlines, the company designs customised versions of its standard products and manages their maintenance and operation over the product lifetime. This entails considering the requirements of both airlines and air-framers at the earliest stages of design. The framework in chapter 5 identified three stages of value creation, resulting in the development of product-service offerings to create customer value. The consideration of different customer needs can be incorporated as shown in figure 6.5, which suggests the need to consider, separately, the needs of each customer as well as the needs of the company. This diagram also shows the three categories of design activities described in chapter 4. The changing strategic position of the company is likely to demand the development of capabilities in different areas. Notably, the interviewees did not report a great deal of activity under the category of customer-facing design. Efforts by the CFBUs to gain a greater understanding of airline customers and their needs suggest that this may change in future. Likewise, the outsourcing of manufacturing operations which results from an effort to focus on product design and service delivery means that the type of business-facing activities conducted have changed. Supply chain design has grown in importance while less manufacturing process design may be required if less manufacturing processes are carried out.

Overall, the role of design in this organisation can be described in terms of integration: of the needs of different customers into a single specification for each component; of a collection of components into a complex product; of a distributed set of suppliers into an efficient supply chain; of a number of specialised technical skills and departments into teams; and of a range of products and services into an offering which delivers value.

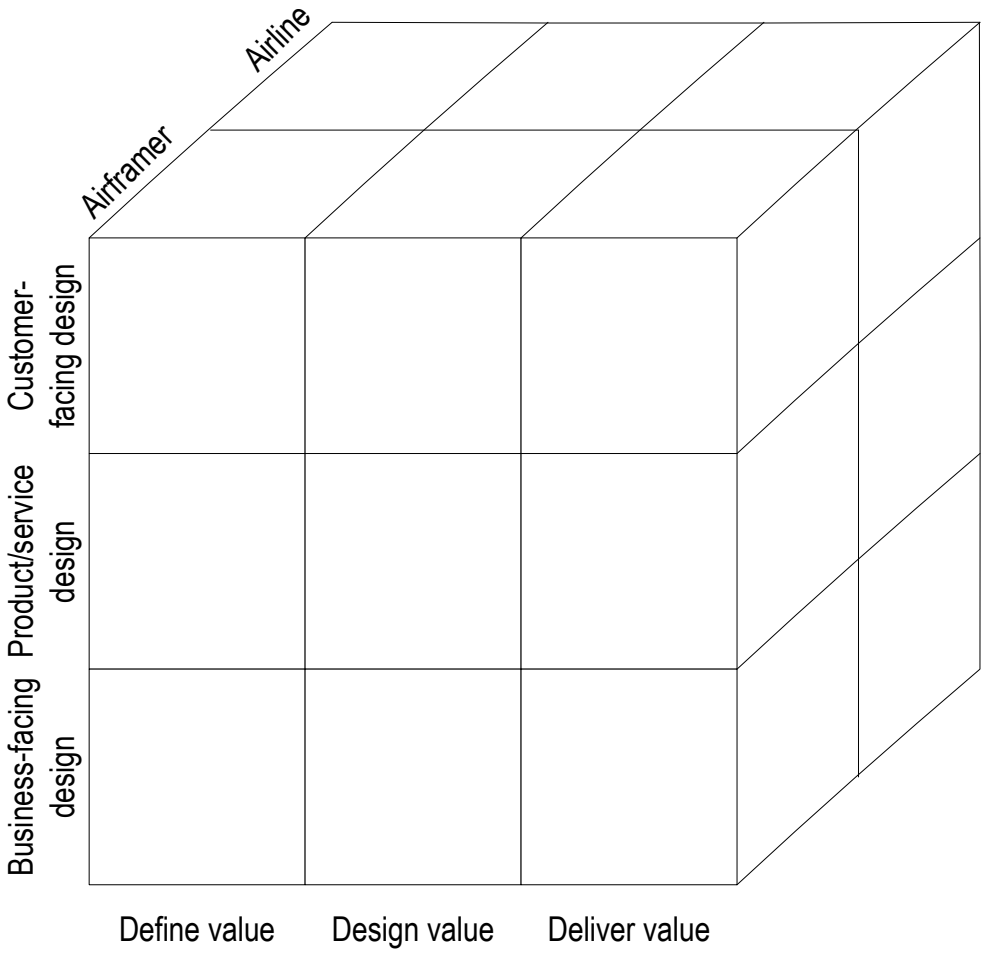
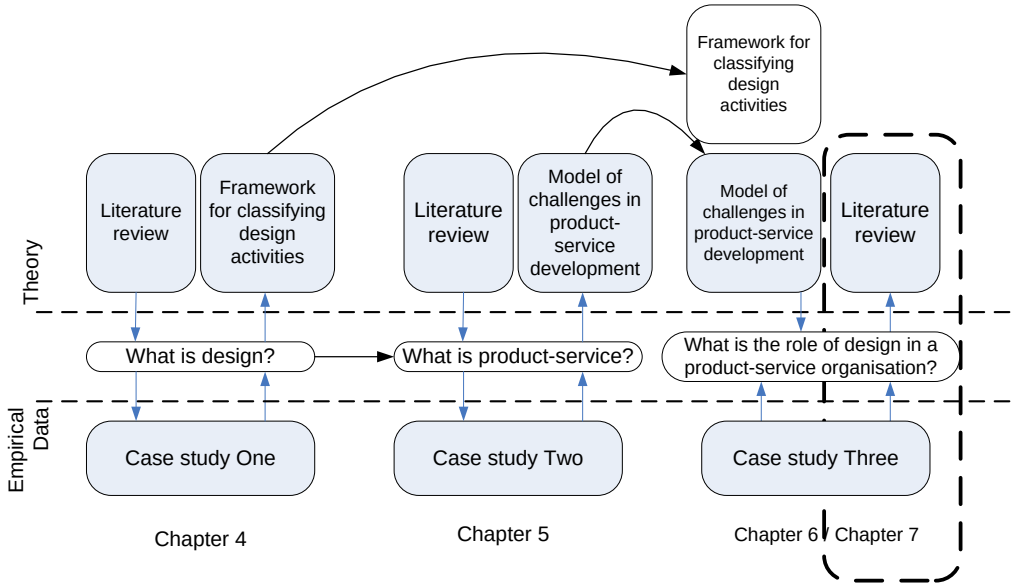


figure 6.5 – a model linking stages of value creation, types of customers and categories of design

Chapter 7
Organising for Product-Service Design

> *"…we just have one big process and each person knows just where they sit and what they're responsible for. It just so happens that they're in different companies…"*
>
> (Executive, Marketing, Services, April 2010)

This chapter examines the findings of the research and positions the contribution within existing theory. Case study three produced insights on aspects and topics which had not been considered in the review of literature conducted prior to the data collection. Therefore these insights led to a further review of literature which helped to explain the findings and enabled their novelty to be shown. This chapter discusses literature and empirical findings related to the nature of a product-service transition, the resulting modification to the organisational structure, multi-disciplinary teams and design capabilities arising from this transition.



In the previous chapter, the role of design in a product-service organisation was examined, using a theoretical framework developed through studies of design and product-service respectively. The findings of the previous chapter related to four aspects of a case study of an aero-engine producer, which operates as a product-service organisation:

1. The nature of the product-service transition and the role of design in making this transition.
2. The role of design capabilities and their re-alignment in a product-service organisation.
3. The customer facing structure developed to accommodate the design and development of product-service offerings and the required interaction with customers.
4. The multi-disciplinary teams used in the design and development of product-service offerings.

For each of these four topics, the insights from empirical research are discussed, before a review of literature is presented. The point of departure from the literature is therefore made clear, helping to position the contributions of this research.

7.1 Product-service transition

In this research, design was investigated within the context of companies involved in a product-service transition, or servitization. Initially, the researcher considered that this transition involved a simple change from manufacturing to service provision. Instead this transition was observed as a move 'downstream' (Wise and Baumgartner, 1999) or 'up the value chain' (Neely, 2008) or, as a change in focus from products to customer processes (Oliva and Kallenberg, 2003). It can be argued that servitization

represents a company's attempt to shift its position, to take over their customers' processes, in the hope of capturing greater revenue over a longer term. From this perspective, Aero-Engine Co. can be viewed as taking over the management of its customers' engines and seeking to deliver power, the output of managing and operating the engines. One interviewee offered the following description.

> *"If you think about the whole thing as just a big process that's just about running engines, at the minute all of our processes are just chopped up. The airline has a particular process, that's it, we have a particular process, that's it. When you get past that, we just have one big process and each person knows just where they sit and what they're responsible for. It just so happens that they're different companies but ultimately you want one process that feeds the next and not just stop and have to wait for somebody to pick it up."*
>
> (Executive, Marketing, April 2010)

This one big process may look something like the chain shown in figure 7.1, which was based on another interviewee's (Executive, Supply Chain, May 2009) description of the transition as a move towards the end-user. At one end are the companies which supply commodities and components which go towards the production of the engine and at the other are passengers, who fly in aircraft powered by these engines. He considered the engine to be the most technically complex part of the aircraft and therefore argued that the capability to develop engines could theoretically allow the company to develop aircraft and replace the airframers to which it is a supplier. It seems unlikely that the company will attempt to usurp its main customers and the investment required to reach this position seems to preclude them from attempting to do so. Although it seems unlikely that Aero-Engine Co. will seek to usurp the airframers, it has an ability to change its position in the market which is not open to some other suppliers, who are likely to remain as component manufacturers. The main difference is arguably the complexity of the product and the knowledge of this product, which gives Aero-Engine Co. an unrivalled advantage.

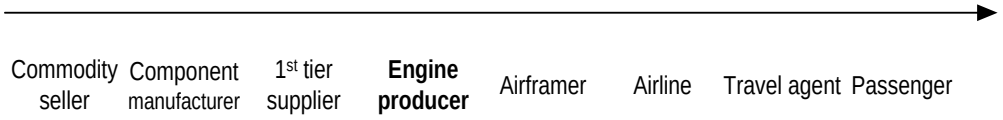


figure 7.1 – A chain of processes showing the position of Aero-Engine Co.

As described in chapter 6, one of the key elements of Aero-Engine Co.'s product-service offerings is the use of condition monitoring technology, offering a valuable source of knowledge. Service contracts mean that customers agree to give data to the company, which they would otherwise have no incentive to do. The benefit for customers is that the data will allow scheduling of repairs at the least disruptive opportunities. For example, identifying a potential problem weeks before it becomes disruptive, allows a suitable repair to be scheduled to suit capacity and location of resources and spare parts. For the

company, the added benefit is a wealth of knowledge on how their products have performed, which could not be gained through physical testing and is potentially more accurate than virtual testing. This knowledge contributes to the design process in a number of ways. Firstly, it allows virtual models to be enhanced, and improve the ability to accurately model and test components at the design stage. Secondly, where time constraints require experience to be used in making estimates or taking 'rational risks' (Executive, Supply Chain, May 2009), having more data to base decisions on is invaluable. Finally, product knowledge is an important resource for the company, which enables it to design products and this, in turn, makes product-service offerings possible. This knowledge is particularly important since it functions as a barrier to entry, preventing other companies from entering the market as competitors. Knowledge gained over many years has allowed products to be designed and is enhanced through the collection of real time engine performance data through condition monitoring.

Rather than supplying the airframer who then sells the whole product to the airline, Aero-Engine Co. is able to offer products and services directly to the airlines. Product knowledge, built up through years of designing and building aero-engines, gives the company a strong position and means new entrants cannot be foreseen taking their place in this chain (Chief Engineer, R&T, April 2009). Since the airframers lack this knowledge, they can position themselves as systems integrators (Davies et al., 2007) but rely on Aero-Engine Co.'s ability to design engines. Therefore the unique market conditions, the presence of a large installed base of products and the company's design capabilities and product knowledge have enabled them to offer services to airlines. In particular, the ability to design products can be seen as an enabler of servitization, whereas the ability to manufacture the products is clearly considered less important, as evidenced by the company's increased outsourcing of manufacturing processes.

Product to process transition

Oliva and Kallenberg (2003) identified that a product-service transition was generally understood as a change in the relative importance of tangible goods and services, with one or the other being seen as an 'add on'. From this perspective, the transition is seen as a move from pure manufacturing to pure service. The focus of their research was on how far manufacturers go on this continuum and why they decide to go no further. Oliva and Kallenberg studied 11 capital equipment manufacturers, through interviews with their service division heads and CEOs. These included companies at different stages of transition and involved in the manufacture of different products, some of which are traditionally more open to service than others. Following their study, they categorised the transitions of these companies along the two

dimensions of product to (end-user) process orientation and from transactional customer interactions to relational interactions. Advancing in the two dimensions results in a pure-service organisation, which assumes responsibility for and takes over the risks inherent in, the end-user's processes.

Windahl and Lakemond (2010) adapted Oliva and Kallenberg's two dimensions, mapping product-service solutions in a two by two matrix, according to the ownership of the product part of the offering (either owned by the customer or the supplier) and the focus of the service part (on the products or the customer's processes).They recognised that the world is not straightforward enough for everything to fit neatly in one of these boxes and, following the discussion in the previous chapter it is clear that 'ownership' is not as straightforward as previously expected. As this research has done, Windahl and Lakemond related their conceptualisation to the rental/access paradigm, but they acknowledged that decisions about ownership in the capital goods sector (as with aero-engines) are complicated. Some of the equipment is owned by customers, some by suppliers, rather than being all owned by one or the other. While the services delivered as part of the solution resemble outsourcing, the integration of suppliers' and customers' processes means that a close collaboration and risk sharing are required, resulting in a high level of interdependence between customer and supplier. Oliva and Kallenberg (2003) highlighted the value of condition monitoring, commenting that while many companies have achieved the technological feat of developing it, most fail to capitalise on the technology. Capitalising on condition monitoring requires the customer to depend on the supplier for management of its processes. Windahl and Lakemond (2010) also saw a product-service transition as resulting in interdependence between customer and supplier. They saw different types of product-service offerings on a scale which showed the increasing interdependence of supplier and customer. They saw these offerings, particularly the "fully-fledged integrated solutions" at the end of the scale, as a sophisticated form of outsourcing whereby the customer pays for the result of a process and the supplier takes control of this process from the customer. This results in a loss of control over the process and subsequently a loss of relevant knowledge about it, which Windahl and Lakemond (2010) argued makes this approach suitable only for non-core processes.

Customers receiving product-service offerings can be seen as outsourcing their processes and paying for the result. Similarly, Davies et al (2006, 2007) found that the providers of the offerings were likely to have outsourced many of their non-core processes in order to focus their attention on the services they delivered. They studied five international companies from different sectors including telecommunications,

electronics and transportation and classified as manufacturers or service firms but delivering integrated product-service offerings. They identified that the manufacturing companies had sought to sell off production facilities, and some had outsourced up to 90% of component production. While component manufacturers seek to compete by becoming the best in the world at supplying a few products they considered that the companies in the study had positioned themselves as systems integrators. These are companies responsible for "general system design, selection and coordination of a network of external component suppliers, integration of components into a functioning system, and the development of technological knowledge needed for future systems upgrades". In short, the capabilities to design products were considered core, while production of the components was regarded as expendable. The capability to manufacture the components, however, was replaced by the capability to co-ordinate the suppliers and manage relationships with customers.

Servitizing the core offering

In the 2007 EurOMA conference, Neely (2007) argued that the benefits regularly proposed as resulting from a product-service transition were often assumed by researchers, but not necessarily proved. Several descriptive case studies had investigated the nature of the offerings but did not go far enough in testing the actual benefits. To overcome this limitation, Neely's work focused on a search for generalisable, quantitative findings on the benefits of servitization. His initial study (Neely, 2008) showed evidence that 'servitized' manufacturers were more likely to go bankrupt than 'non-servitized' manufacturers. The study involved analysis of data from approximately 10,000 companies in manufacturing sectors (classified by Standard Industrial Codes) obtained from the OSIRIS database of which approximately one third were considered to be 'servitized' since their descriptions included one or more of a list of 12 services. Of approximately 200 bankrupt firms in the dataset, a higher proportion were 'servitized' leading to the conclusion that servitization can have an adverse financial impact. Further investigations, focusing on the set of bankrupt firms and using qualitative data to investigate the reasons for their bankruptcy, revealed a more complex situation (Benedettini and Neely, 2010). One interpretation of the later results is that those firms which had 'servitized' by offering additional services which were not closely related to their core offering were those which had gone out of business, while those which had offered closely integrated services had not been as badly affected. As a result, the first study suggests that servitization negatively affects financial performance while the second suggests that offering services too far removed from the company's core offerings is the real danger.

Fang et al (2008) investigated the impact of adding services in manufacturing companies, identifying that a critical mass must be achieved before the benefits are felt. They studied data from 477 publically traded manufacturing firms, comparing the proportion of revenue from services with a measure of the firm's value, using Tobin's q which is based on stock prices and incorporates sales, profits, cash flow, earnings and volatility. They identified that firm value remained low or even negative until service revenue reached a certain point between 20 and 30%. The results varied by industry, but showed that the impact was more likely to be successful when the additional services offered were closely related to the core offering. The proportion of revenue a company gains from services as opposed to manufacturing is often assumed to indicate its level of servitization. Yet Neely's results (Benedettini and Neely, 2010) demonstrate that struggling manufacturers who begin to offer services may have a higher percentage of revenue purely because their manufacturing business is failing. The lesson from both Neely and Fang et al.'s studies is that servitization is not as simple as replacing products with services, but that the type of services offered – and how closely related they are to the firm's existing core offering – play a part in their success.

Findings

The literature highlights that servitization, rather than being a simple move from manufacturing to service provision actually involves a change in focus towards customer or end-user processes. This lends support to the findings of the Aero-Engine case study which highlighted the company's ability to offer services to its customers' customers (moving towards end users) as opposed to remaining as a component supplier. The literature also suggests that the benefits of servitization are most likely when services offered are closely related to the company's capabilities as opposed to unrelated services. The main contribution of this research to the argument is to highlight the importance of design capability as an enabler of servitization. Aero-Engine Co.'s main advantage over other companies is its ability to design highly complex products. It is able to act as a systems integrator in co-ordinating the manufacturing of these products, showing that manufacturing capability is less critical in this respect. Product-service offerings can also be expected to strengthen the company's position since they increase the company's knowledge of customers and products, enhancing the ability to design future offerings.

7.2 Design capabilities

Returning to the design case studies in chapter 4, the product-service transition of Aero-Engine Co. can be compared to the attempted repositioning of Tiling House. The company previously sold tiles to builders and property developers, competing on price by offering considerable trade discounts. An attempt was made to sell directly to home owners, representing a move towards the end user. Selling to these customers required more customer facing design, for example making the retail space more attractive. It also demanded the ability to offer services, in this case a design service, to provide a more complete offering to the customer. Staff were given training in interior design, to enable them to deliver the service to customers, while design graduates were employed, increasing the company's design capabilities.

Tiles are a relatively simple product, so that no modification in the product would be required to sell it to a different category of customer, although significant changes to the service were required. In the Aero-Engine case, however, meeting the requirements of different customers was a greater challenge, bringing implications for products and their design requirements. This is largely due to the fact that products are developed for one customer – the airframer – on the same terms as they were prior to the product-service transition and then customised and form the basis of the service sold to another group of customers – the airlines.

The two groups of customers have different requirements, which are satisfied by the same product. In the case of the airframer, requirements are related to the technical performance of the engine, for example the power output and characteristics which affect the functioning of the aircraft, such as the weight. Innovation in technology is required, in order to offer a superior product to rivals, which also seek to develop engines for the airframer's aircraft. Equally, efficiency in the development process is important, to ensure the engine is developed and tested to fit time and cost targets and is ready for flight tests. For airline customers, particularly those opting for service contracts, rather than buying the engines, the requirements are different. Technical performance and technological innovation are not priorities, assuming the engine is capable of powering the aircraft it is intended for, which the airframer is expected to have ensured. Instead considerations such as reliability and fuel efficiency are paramount, since these have a clear impact on running costs and hence the profitability of the airline. In giving the airline a predictable cost per flying hour, and in developing a product which reduces the fuel and maintenance

components of this cost, the company is able to make its offerings more attractive. Technical requirements can also vary between different airlines. Rather than using the standard configuration developed for the airframer, the design may be optimised for each customer, in some cases resulting in a unique product design, which in turn requires a supply chain re-design.

The design of products can be seen in two stages. First, a product platform is developed, in this case in a collaborative process to satisfy the requirements of an airframer. Secondly, the platform is customised and modified to meet specific technical requirements before being delivered to service customers, in this case the airlines. Additionally, since services are offered, many aspects which have traditionally been dismissed as 'non-technical' are becoming increasingly important. Since the sustained revenue of the company depends upon its ability to maintain engines efficiently, managing the logistics of overhaul and repair bases is a major concern, as highlighted in chapter 5. This has seen the development of supply chain design, including the introduction of a standard role of supply chain designer and formal tools and processes which "give them more teeth" (Executive, Supply Chain, May 2009). The role of supply chain designer is an important example of how design activities outside of the engineering functions have been identified and formalised in the NPI process. This can be considered an attempt to improve the efficiency of these activities, in other words to make the silent design more 'audible'.

The supply chain designers and their training in Aero-Engine Co. can be compared to the interior designers and training introduced into the workforce at Tiling House. Both can be considered as an attempt to develop design capabilities in order to adapt to a change of operating environment caused by servitization. Previously, it was argued that design is an enabler of servitization which allows the company to move along the chain shown in figure 7.1. Moving any further along this chain, however, would require capabilities which the company is unlikely to have. When one considers the processes operated by airlines or travel companies, the ability to design complex engines does not seem to fit with the hospitality and marketing capabilities which these companies require. By investigating design activities, the case study in chapter 6 revealed that the type of business facing design capabilities are being re-configured. The effort to formalise supply chain design and better equip supply chain designers is important since the company's production is mostly outsourced. As Davies et al (2003, 2006) argued, this outsourcing goes hand in hand with a product-service transition when the company seeks to be a systems integrator rather than a manufacturer. The ability to design products and co-ordinate their production and delivery puts Aero-Engine Co. in a strong position to integrate their suppliers' components

to deliver to airframers' requirements. One thing they arguably lack, however, is knowledge of the airline customers (Executive, Marketing, April 2010) who are further along the chain. It was suggested that efforts have begun to focus on increasing this knowledge of customers, for example by conducting a research exercise to understand the airlines and their processes better.

Reconfiguring capabilities

Davies and Hobday (2005) introduced the concept of path dependence to the product-service literature, arguing that the approach taken by an organisation or a part of an organisation will depend on their history, in terms of past investments which enable or constrain future change. This concept is closely linked to dynamic capabilities (Teece et al., 1997), which describe a firm's ability to reconfigure its operations in response to changing environments as a key factor in its ability to compete. The strategic management literature has, in recent years, paid increasing attention to the concept of dynamic capabilities. It is primarily concerned with the processes firms use to renew or re-organise their resources in order to compete in 'dynamic' environments. The dynamic capabilities perspective therefore follows from the resource based view (RBV, Barney, 1991) of the firm, in which a firm's resources are seen as the source of its competitiveness. This is regarded as a static view (Lockett et al., 2009) whereas the dynamic capabilities perspective assumes that these resources must evolve over time in order to sustain competitiveness.

In a review of the strategic management literature Ambrosini and Bowman (2009) identified studies which took a dynamic capabilities perspective to investigate various processes. They highlighted studies of R&D; acquisitions and product innovation (Danneels, 2002) among a relatively small number of empirical studies of dynamic capabilities. In the Operations Management literature, one study investigated design (specifically design creativity), arguing that it is a 'static' rather than dynamic capability (Azadegan et al., 2008). The study argued that creativity must be 'bought' rather than 'made', although Makadok (2001) states that dynamic capabilities are embedded in an organisation and must be built rather than bought in the market. Ambrosini and Bowman (2009) argue that the word dynamic is a source of confusion and that dynamic capability should not be decomposed into two words, but rather seen as a single construct.

> *"A dynamic capability is not a capability in the RBV sense, a dynamic capability is not a resource. A dynamic capability is a process that impacts upon resources."*
>
> (Ambrosini and Bowman, 2009, p34)

Danneels (2002), described capabilities as the ability to accomplish something by using a set of material and immaterial resources. He argued that product innovation is a dynamic capability since it both results

from and contributes to the renewal of a firm's capabilities. He argued that previous literature had acknowledged that innovation results from capabilities, but had largely overlooked the feedback of innovation into the firm's capabilities. Specifically, he focused on technology and market related capabilities as being critical to product innovation. Design has long been considered to act as a link between a company's technical and market related capabilities (Kline and Rosenberg, 1986, Rothwell, 1992), contributing to design being seen as an important strategic tool (Kotler and Rath, 1984). Therefore it may be appropriate to consider design as a dynamic capability, similar to innovation.

Danneels' distinction between technology and market is similar to Livesey and Moultrie's (2009) divide between technical design (related to engineering and technology) and non-technical (related to customers and communication). In their study of design spending in UK manufacturing firms, they reported an estimated spend on technical design to be four times that of non-technical (Livesey and Moultrie, 2009). This can be expected since technical design can be expected to include costly equipment and engineering effort, which would make spending higher than non-technical. There is a danger, however, that non-technical design was underestimated by respondents since it captures resources that are out-with a company's design department or otherwise not readily considered as design effort. The difference between technical and non-technical design may be an indication of their relative importance as perceived by individuals in a company. As seen in Aero-Engine Co. the non-technical activities are carried out in a less formal and less structured way than technical activities.

Findings

In studying design within the context of servitization, this research has made use of the concept of design capabilities. These capabilities include the knowledge which enables design, either as the tacit knowledge of individuals or codified in the tools and processes used to carry out design. As well as enabling servitization to take place, these capabilities are considered to constrain the extent of servitization, for example, allowing Aero-Engine Co. to sell services to airlines (the airframers' customers) but not to sell travel to end users (the airlines' customers). This research also suggests that the design capabilities change to adapt to the new organisational environment which results from servitization. In this instance, the development of supply chain management as a design capability and the attempts to develop customer knowledge were seen as indications of this. The concept of design capabilities is related here to the strategic management literature on dynamic capabilities. From this perspective, the ability to re-organise resources (design capabilities) to adapt to a dynamic environment (servitization) is

the source of the firm's competitiveness. Design can therefore be seen as a dynamic capability similar to product innovation, as identified by Danneels (2002) but it is produced by a set of resources, which can be reconfigured by other dynamic capabilities to adapt to servitization.

7.3 Organisational structure

As described above, servitization results in a change in the type of relationships a manufacturing company has with its customers. Delivering services brings the opportunity to interact more closely with customers, which in itself is a challenge. In chapter 6, the relationship with customers was explored in the context of the organisational structure developed to manage these relationships in the process of designing and developing products. The organisational structure in Aero-Engine Co. follows an approach of restricting communication with customers, shielding staff from customer pressure and managing the contact with customers which is a vital part of service operations. Designers in Aero-Engine Co. are normally very specialised, experts in particular technical functions. They may be "wheeled out" (Executive, Supply Chain, November 2008) to impress customers, but most customer interaction is dealt with by teams within CFBUs who specialise in managing the customers. While some would consider that everyone in a service organisation should be customer oriented (e.g. Galbraith, 2005), this does not appear to be the case in Aero-Engine Co. where the SCUs treat project teams and CFBUs as their customer. While the CFBU staff have received training aimed at introducing a service culture, the company's product-service transition has had little direct impact on many of their colleagues in SCUs. Some would argue that this is a problem to be addressed. On the other hand, this could be seen as a sensible approach for an engineering focused company to take – allowing the engineers to do their jobs, while the customer relationships are handled by specially trained teams.

The SCUs in the company are more than simply support functions and the product-focused functions cannot be seen as merely the 'back-office' of a service. It is clear that engineering dominates the company and the rhetoric of this being a service company is repeated but not fully supported. The engineers are often considered to be untouchable, while others, including the CFBUs are expected to be more flexible:

> *"…you can give a lot of pressure to operations. You can give a lot of pressure to the customer focal points or anything. What you can't do, you can't put pressure on the engineers because they are dealing with safety issues and you aren't allowed to give them pressure. "*
>
> (Chief Engineer, R&T, April 2009)

For Aero-Engine Co., engineering design is key to the development of products and, consequently a key part of the company's service offerings. For this reason, engineers and designers have traditionally had a privileged status in the company. This was revealed when interviewees showed their pride in technical achievements, rather than service contracts. Public presentations by the company normally convey its longevity and describe its success in positioning itself as a service company. Yet they also refer, again with a clear sense of pride, to the company's technical excellence. In this context, rather than being seen as the most prestigious part of the company, the CFBUs may even be regarded as having to do the unenviable job of dealing with customers. They were described as being "on the front line" (Logistics Manager, R&O, April 2009) which has very different connotations to being the 'front' of the front/back structure.

A slightly unexpected perspective was that the CFBU acts as a 'buffer' (Supply Chain Manager, SCU 5, April 2010) to protect those designing products from the whims of customers. This role was also observed in the case study of Perfect Peach which was described in chapter 4. In that company, the technical, back-office functions are graphic design and software programming. The back-office is shielded from customers by having all interactions go through a dedicated sales team. As with the CFBUs in Aero-Engine Co., the sales team has sufficient technical knowledge and customer relationship capability to liaise between the two sides. This relieves pressure on designers, while providing them with specifications to work to, rather than interpreting the voice of the customer directly.

Having a buffer between the product-facing back and the service delivering front of the organisation has an added benefit which has not been explicitly identified by most authors. While many argue that everyone in a product-service organisation should consider the end user, and a service culture is required throughout, there is a suggestion here that the CFBU has alleviated the need for this service culture. Moving to a service culture is easily prescribed but less easily implemented and the CFBU, therefore, may be a relatively simple way of restructuring the organisation without implementing wide-spread change. What remains to be seen, however, is whether this buffering role can be permanent or whether it should be a temporary one, with the widespread implementation of a service culture coming later.

Front/back structure

Windahl and Lakemond's (2010) review of literature suggested that authors describing a product-service transition tended to overemphasise the distinctions between products and services. Meanwhile, those

focusing on the strategic and organisational requirements of such transitions were almost unanimous in proposing a front/back structure. This sees the development of customer-facing units as the front, with the product facing parts of the business being considered the back. Meanwhile, studies which adopted a service-dominant logic perspective were overly focused on consumers rather than organisational and strategic issues. In a perhaps unique study, Tuli et al (2007) sought to examine both customer and supplier perspectives, to understand the implications of a product-service transition on both. The study involved interviews with managers from 25 customers and 29 providers of product-service offerings. They identified that the providers focused excessively on how to integrate products and services, while customers were more concerned with relational processes. By this they meant that customers placed more emphasis on the interactions they had with the company and its employees in requirements definition, customisation of products and services, their deployment and customer support. They identified that the measures of effectiveness differed, with providers emphasising functional aspects of the offerings while customers were more concerned with relational aspects, such as how well the provider had understood their political and operational environment. Tuli et al did not report whether these providers had implemented a front/back structure, although they provide evidence that a cultural difference exists between those providing and those buying product-service offerings. This cultural difference is something which should be addressed by manufacturing companies to enable them to offer services.

For Galbraith (2005) companies move from being product centric to increasingly customer centric but he argued that many are not initially equipped for the organisational requirements of this change. He prescribed different levels of customer centricity, measured by the scale and scope and required level of integration of the offerings provided by the company and demanded by the customer. Scale and scope refers to the complexity of the offering, for example providing a Local Area Network (LAN) linking 12 computers in a workplace rates very low, providing a CAD system for the use of 100 engineers and an entire trading floor for a financial services business employing thousands was regarded as very high. Meanwhile the level of integration refers to the ease with which the components of the offering, whether individual products or services, can be combined together. As shown in figure 7.2, Galbraith prescribed approaches for each level of customer-centricity, inviting companies to position their offerings on this scale and implement the appropriate organisational approach. These range from voluntary groups to share information between parts of the organisation on individual customers, to a complete restructuring

in order to organise around the customer. Galbraith's vision of organising around a customer involves customer facing units dedicated to serving each individual customer or sector. These units are in the front line and their role includes designing a solution which makes use of the product units' output. The product focused back of the organisation is seen as producing generic standard products, while the customer-facing units create higher value integrated product-service offerings.

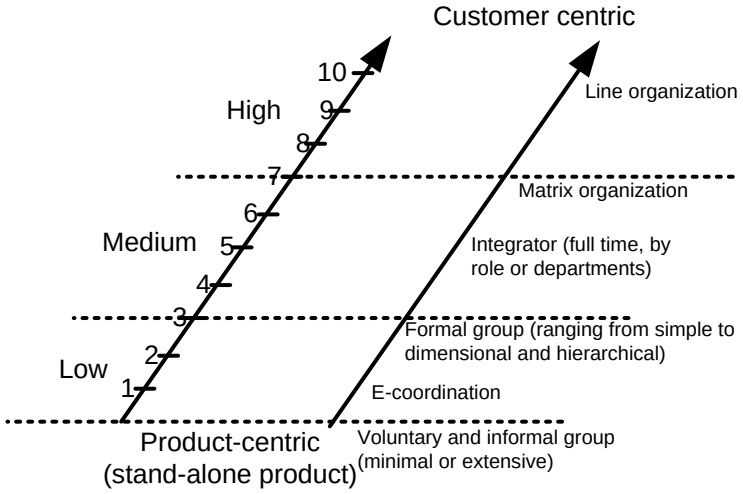


figure 7.2 – levels of customer-centricity and organisational approaches suited to each level (Galbraith 2005)

Leiringer et al (2009) reviewed the product-service literature, seeking to investigate its applicability in the construction industry, where Private Finance Initiatives involve a company co-ordinating the construction and maintenance of a building on behalf of a customer. They found that the literature presented the product focused back of the structure as being downgraded in status, for example suggesting that existing contacts would be given up to the customer facing part of the organisation. They referred to Foote et al.'s (2001) insistence that product-facing units should "swallow their pride" for the greater good. Meanwhile the customer-facing unit enjoys an exulted position since it is responsible for relations with customers and delivering services. Leiringer et al's (2009) study of three operating units within a construction company found a tendency to establish specialist units for the purpose of winning PFI contracts. Externally, the organisation was seen to have adapted to have been restructured, yet internally, they found the institutionally embedded operating routines to be largely unchanged. In a similar study, Johnstone et al (2009) found that, even when there is an overall corporate strategy, the development of product-service offerings within different divisions of a single organisation can vary. The approaches were found to be responsive to peculiarities of the markets which these divisions operated in and the type of offerings they produced.

Chase and Garvin (1989) argued that manufacturing staff, responsible for running the factories which make products, are the best qualified to offer customers advice on the use of those products. Their suggestion was that manufacturing personnel offer a valuable resource to companies wishing to offer their customers services in addition to the products they currently buy. Previously, however, Chase (1981) had proposed the customer-contact approach to services, in which he argued that the more contact is required with customers, the less efficient an operation will be. This would suggest that the efficiency of manufacturing personnel will be protected by shielding them from customers. Several writers have suggested that designers possess an almost instinctive understanding of customer needs (e.g. Verganti, 2009) or a particular cognitive approach which makes them well suited to dealing with customers problems (Brown, 2008). Many companies, however, deliberately keep their designers away from the pressures of customer interaction. For example, Bangle (2001) described how designers at BMW were given freedom to focus on product excellence by being protected from dealing with financial people. He gave an example of a member of the design team worrying about the feel of the material intended for a car interior and ensuring the product would be right, while their managers would deal with the financial concerns. Lorenz (1986) also described successful companies such as Sony, which sought to shield their designers from certain commercial pressures. Equally, queries from customers or direct interaction can be time consuming to deal with and slow the NPI process.

Findings

The literature is almost unanimous in proposing a front/back structure, i.e. prescribing the introduction of a customer facing 'front' and the repositioning of manufacturing operations as the 'back'. This is to compensate for a difference in 'culture' between operations personnel and customers, as highlighted by Tuli et al (2007). Most authors either explicitly state or implicitly suggest that this difference in culture must be addressed by the widespread introduction of a service culture. In contrast, this research proposes that the recommended cultural change is not only highly challenging but may also be unnecessary. The customer facing front was considered as a buffer which helps to minimise the impact of cultural differences. This approach was compared to that of other companies which seek to protect designers from interactions with customers. Although there are disadvantages to creating a distance between designers and end-users, designers of complex products, or components of such products, can also benefit from the opportunity to deliver to specifications rather than communicating with and satisfying demanding customers. This relies on customer facing units which are able to manage customer

relationships but also have sufficient technical capability to manage relationships with their colleagues in product facing roles.

7.4 Multidisciplinary teams

The evidence of the Aero-Engine Co. case suggests that engineering design remains critical to the success of the product-service offerings, but the interviews revealed that the involvement of other functions in the design process has increased in recent times. While technical excellence is a source of pride, a major part of the company's image and therefore an overall aim for the company, manufacturing feasibility and commercial viability have become much higher priorities in recent years. This is partly, if not entirely, a result of the requirement to manage the total lifecycle costs of products in order to deliver profitable services. This requirement, in turn, has led to a greater involvement of other functions in the NPI process, for example the inclusion of supply chain designers in component IPTs, to ensure consideration of the supply chain implications of product design. Engineering must come first, since it is impossible to design a supply chain before the product has been specified, but there are signs that other functions have a greater influence over the engineering design process than may have been the case in the past.

Manufacturing and component design activities are now largely conducted within Supply Chain Units. While the name suggests that their main role is managing suppliers, in fact the SCUs are an effective means of creating differentiation (Lawrence and Lorsch, 1967a) in the company. Each SCU deals with a potentially very different sub-environment, which means they work in very different ways and with very different approaches to manufacturing and design. In SCU 2, for example, the layout of factories which produce 80% of the SCUs components places restrictions on the design of shafts (Manufacturing Manager, SCU 2, April 2009). Meanwhile in SCU 5, where 80% of components are manufactured by suppliers and many are designed by partners (Supply Chain Manager, SCU 5, April 2010), it is very common to work with other companies. A deeper study could identify different organisational cultures within this organisation, although this is not the purpose of the present research. The SCU structure, however, makes it possible to have these different cultures and environments, which are suited to the internal environment, influenced by the products they deal with, and the external environment influenced by suppliers and competitors.

As will be discussed, differentiation between different units of a company is important, since it allows the units to be specialised to the demands of their particular sub-environment, but integration between these units is necessary for the benefits to be achieved. In Aero-Engine Co.'s design process, the integration is achieved through the use of IPTs, which create temporary groups comprised of all of the relevant functions from an SCU. The IPTs bring technical and non-technical specialists together to work on design projects, resulting in a complete design of a product and its supply chain or production process (depending upon the product and the SCU). The movement of staff between their business function and IPTs also enables a transfer of knowledge throughout the organisation since employees gain an understanding of what other, specialised and differentiated departments do and enhance their ability to work together in future.

Structuring multi-disciplinary teams

The concepts of differentiation and integration emerged were investigated by Lawrence and Lorsch (1967a, 1967b) who carried out an influential study of organisations to understand how they should be structured to deal with different environmental conditions. While other studies focused on one part of an organisation, Lawrence and Lorsch sought a much more holistic scope by comparing similar departments in different organisations. They argued that the organisations should not be seen as a single entity, operating in one environment. Rather each of the units they investigated was seen to operate within a different sub-environment, requiring different attitudes and different approaches to the others. They measured variables such as the uncertainty of knowledge in the environment and the orientation to time. For example, market knowledge is uncertain, but to a lesser degree than scientific knowledge and a greater degree than production knowledge. The key concepts for Lawrence and Lorsch were integration and differentiation, which they recognised as being conflicting but necessary objectives. The most successful organizations were those which not only achieved the highest integration but also had the highest differentiation. Integration is easier to achieve when the units are not differentiated greatly, but success requires both to be high (Lawrence and Lorsch, 1967a). The organisation, therefore, requires units which are highly specialised and focused on the demands of their sub-environment, while demanding methods of integrating these differentiated units to ensure they are well co-ordinated.

Similarly, Takeuchi and Nonaka (1986) considered the integration of different functional specialists in project teams as a valuable way of organising product development. They described traditional, sequential approaches to product development to be inefficient and limited by the lack of responsibility

taken by each department after they had passed the project 'over-the-wall'. Instead, they argued that product development should be more concurrent in its approach, mirroring a rugby team in its reliance on different specialists working together to achieve a common goal. They considered that these teams, when left to organise themselves and given responsibility to deliver a complete solution, worked hard to combine their skills and carried out successive phases of development in an overlapping manner which brought them to the end faster than usual. They were also able to create innovative responses to problems, due to the range of expertise which enabled them to analyse the importance of different aspects of a complex problem. These teams are expected to encourage learning among the individual team members, who are pushed to overcome unfamiliar challenges and have the opportunity to share knowledge with colleagues they would normally have little contact with. Their return to their own functional departments sees this knowledge transferred across the organisation.

Meanwhile, Martin (2009) considered the creation of teams, to work on temporary projects, as vital for the long term survival of a company. He argued that when individuals come together in a team, to tackle a difficult design problem, this acts as a source of motivation, making them "want to come to work every day" until they solve the problem. These teams create new knowledge for the company, as well as transferring knowledge between different functional areas. Martin saw this as part of a recurring stage in a knowledge funnel, where new problems are identified, solved and the solutions refined into an algorithm which can then be cheaply and repeatedly implemented (and beyond this, to code, allowing the algorithm to be automated). He argued that many companies are successful at solving problems through intuition and risk taking, but go no further in the knowledge funnel. Meanwhile, other companies are very good at working in the latter stages of funnel, taking solutions and turning them into highly profitable algorithms. These companies do not survive indefinitely, however because they are not able to find the next problems which face them, leaving them exposed to what Christensen (1997) referred to as disruptive innovation. For Martin, every company needs functional specialists, who may even be required to do the same job every day, but they also need to have people working on creating new knowledge and distributing it through the organisation. Creating temporary teams, which integrate the specialisations distributed through the company and create new knowledge is one of the hallmarks of what Martin refers to as the design thinking organisation.

In chapter 4, design thinking was discussed in the context of literature arguing that managers, and those who educate them, should alter their approach to problem solving (e.g. Bolland and Collopy, 2004).

Some consider that managers are taught to analyse data showing what has happened and interpret it using methods based on past knowledge. In contrast, designers are considered to deal with possible future states and attempt to define means of reaching them (Martin, 2009). Major challenges arise when these conflicting world views clash and neither is able to understand the other. On the other hand, design is seen as the function which integrates different units operating in different sub-environments, creating a bridge (Walsh, 1996) between, product focused departments such as R&D and customer focused departments such as marketing (Rothwell, 1992). As described above, it is not necessarily designers as individuals who create this integration, but rather the design teams and processes which bring people together to tackle design problems. It could be argued, therefore, that rather than a service culture, a design culture may be what enables the integration required to create product-service offerings.

Findings

The literature, namely the work of Lawrence and Lorsch (1967a, 1967b), identifies the benefits of differentiation between sub-units, allowing specialisation and development of a culture suited to the sub-environment operated in. While Lawrence and Lorsch considered sub-units such as R&D and production, in Aero-Engine Co., products are suitably complex that differentiation has been created between the units responsible for developing and producing each group of components. The SCU structure, therefore allows specialisation to the demands of each group of components. Lawrence and Lorsch, among others, also argue that integration is essential to the success of product development. This integration, between the different functions operating within each SCU is achieved through the use of IPTs. Crucially, the IPTs tackle design problems including the involvement of individuals representing departments (for example a production planner representing production personnel in product design). This engages non-designers and designers alike in design thinking, which the literature suggests is an ideal means of developing and transferring knowledge throughout the organisation.

7.5 Conclusion

This chapter has discussed the findings of previous chapters, focusing on the case study in chapter 6, which builds upon the theoretical frameworks developed in previous chapters. Four topics were identified, having emerged from the findings of the Aero-Engine Co. case study in chapter 6. For each of these, a brief summary of relevant literature was presented to demonstrate the novel contribution of this research and its findings. To summarise, table highlights the contributions of this chapter to each of the topics it

addresses. The findings are compared to those of other researchers, identifying some points on which there is agreement and helping to position the contributions within this literature.

Topic	Points of agreement	Contributions
Product-service transition	A product-service transition represents a move towards the end user and a focus on services previously conducted by others.	The ability to design products is a key enabler of product-service transition.
Design capabilities	Design is an important strategic capability which can benefit companies through development of products and in other less obvious ways.	Design capabilities must be re-aligned to suit demands of p-s offerings.
Front/back structure	Customer facing units are useful and possibly essential for product-service offerings.	Customer facing units are valuable as a buffer, where product facing attitudes dominate the company and customer interaction is potentially problematic.
Multi-disciplinary teams	Multi-disciplinary teams are an effective way of addressing issues early in development and making product development faster.	Involving non-designers in design is both an effective way to deal with the complexity of services and to transfer knowledge across an organisation.

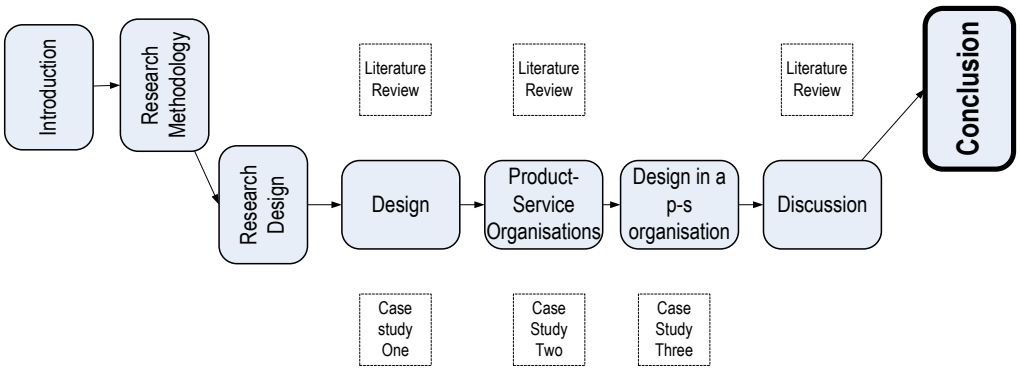
table 7.1 – a summary of contributions to the literature

Chapter 8
Conclusion

"He did not arrive at this conclusion by the decent process of quiet, logical deduction, nor yet by the blinding flash of glorious intuition, but by the shoddy, untidy process halfway between the two by which one usually gets to know things."

(Allingham, 1934)

This chapter concludes the research described in the previous chapters. It summarises the findings and contributions of the research. It then identifies future research topics and practical implications, as well as reflecting on the limitations of the research. The main contribution concerns the link between design capabilities and product-service transition. This research proposes a three dimensional model, linking design capabilities, phases of value creation and types of customers. It is argued that a product-service transition involves serving more or different customers, each of which seek different types of value. Design capabilities enable a transition, but new capabilities may be required for the particular value required by the customers served.



In this chapter, the research is concluded by summarising the main contributions to research and practice, along with reflections on the limitations and consideration of future research opportunities. This research has explored the role of design in product-service organisations. It proceeded from a general position, understanding how design has been studied in previous research and understanding the broad issues surrounding product-service transitions. It then focused on a particular case, examining a product-service organisation in a study informed by the developed understanding of design. The conclusions were compared with existing theory, to identify general implications.

Contributions

The contributions of this research are the following:

- A holistic understanding of design and a method of classifying design activities, which allows the measurement of design effort in businesses.
- An understanding of product-service offerings and a framework to guide the creation and delivery of these offerings
- A set of organisational challenges to be addressed by companies seeking to develop product-service offerings.
- The identification of product-service offerings which demand simultaneous design of the organisation and those for which the product, service and organisation may be separated and involve different partners.
- The identification of design capability as a key enabler of a product-service transition.
- The recognition that design capabilities also inhibit the extent of a product-service transition and require reconfiguration to suit the demands of product-service offerings.

- The proposal that customer facing units act as a buffer which reduces or removes the requirement for organisational change to a service culture.
- The identification of multi-disciplinary teams as a means of involving non-designers in design, which enables the consideration of complex aspects in a product-service offering, as well as disseminating knowledge acrpss the organisation.

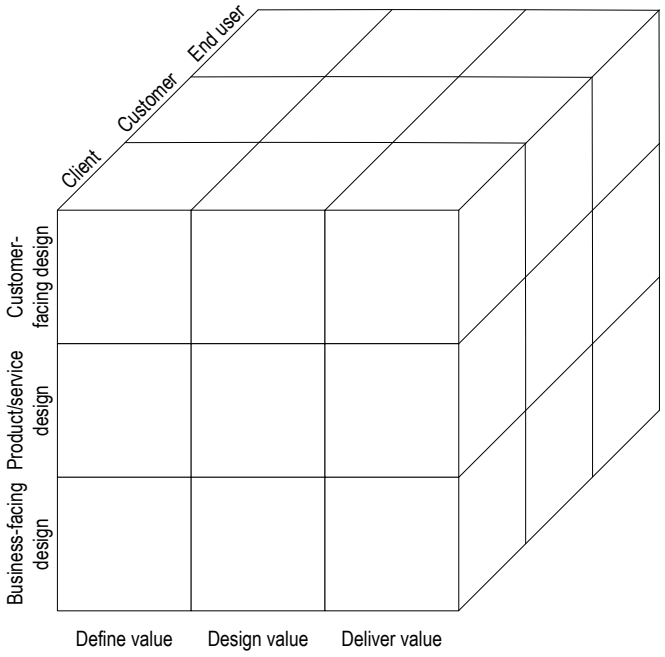


figure 8.1 – A three-dimensional model of the role of design activities in a product-service organisation

One of the key outputs is a three dimensional framework, shown in figure 8.1. This links categories of design capabilities, phases of value creation and types of customers served. It suggests that each of these is an independent construct and that all are related and should be considered together. As demonstrated in chapter 6, this model can be used by researchers, to analyse design in product-service organisations. It can also be used as a strategic tool, to help identify the value to be created for each customer and the design activities which create this value or should do so. This framework emerged from the research described in chapter 4, which developed a theoretical framework for studying design; chapter 5, which identified challenges of designing product-service offerings; and chapter 6, which examined the role of design in a product-service organisation. Each of these concepts was studied in the preceding chapters and will be summarised here.

8.1 Design capabilities

Three categories of design were identified in a study of the role of design in businesses, described in chapter 4. These categories were used to classify design activities, in an attempt to measure design effort. The classification was presented in a number of peer reviewed conference papers, while the researcher contributed to an article in the Design Management Journal (Moultrie et al., 2009):

- Product/service design is the design of the main offering which the company delivers to its customers.
  This category was further divided into the sub-categories of user related and product/technology related design, as shown in figure 8.2.
- Business facing design is the design of background processes and systems which enable the creation and delivery of offerings, but are invisible to customers.
  This category was further divided into systems and processes and organisation and workplace design.
- Customer facing design is the design of anything which supports the delivery, promotion, communication and sale of the company's offerings, but is not a part of the offering itself.
  This category was further divided into design activities supporting specific offerings and those supporting the company and its corporate branding.

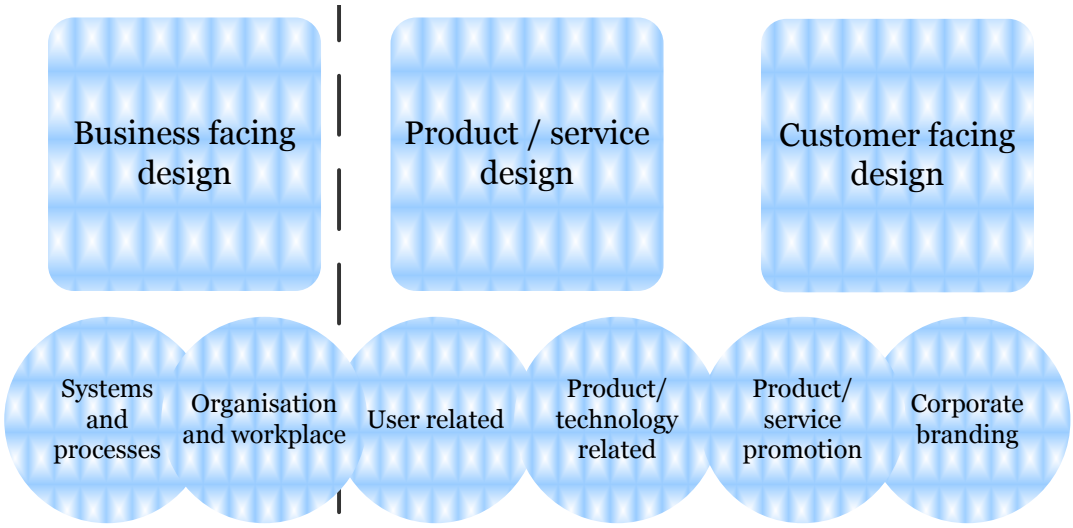


figure 8.2 - Categories of design activities (Beltagui et al., 2008)

These categories can also be used to classify design capabilities. If it can be assumed that design capabilities are required in order to carry out design activities, then a change in design activities will demand a change in the relevant capabilities. For example, if designing services involves vastly different design activities for a manufacturer, then new design personnel, tools, software and equipment may be required.

8.2 Value creation

Three stages of value creation, in the development and delivery of product-service offerings, were identified. These emerged from the study of product-service organisations and the challenges they face in making a product-service transition, in chapter 5. A framework was presented in a number of peer reviewed conference papers and an article in the International Journal of Operations and Production Management (Pawar et al., 2009).

As shown in figure 8.3, the framework highlights value as the key concept in product-service offerings, identifying that this value is what customers seek from products and services. The process involves defining the nature of this value, for example identifying that customers seek 'power' when they buy engines and what can be delivered. It then requires the design of a solution, where the framework implies that the capabilities required to develop, produce and deliver this solution may need to come from external partners. Therefore the service provider does not act alone but as part of a network, it should seek to not only sell its products, but integrate the products and services which can jointly and profitably satisfy customer needs.

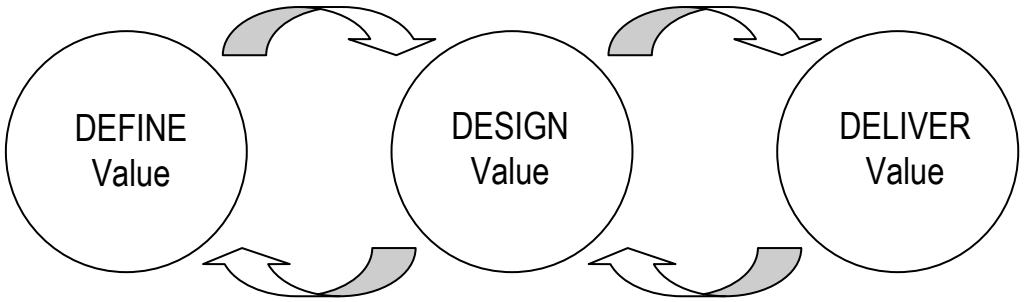


figure 8.3 – A framework for the development of product-service offerings

8.3 Designing for multiple customers

A product-service transition can be seen as a company offering to carry out activities which are normally carried out by customers, or customers' customers and suppliers. As a consequence, a manufacturing

company will be involved in delivering services, in addition to, or occasionally instead of, making products. One implication identified in chapter 6, was that a product can be designed for one customer, but sold as part of a service to another customer. In this case, engines are designed to meet the requirements of an airframe manufacturer, but sold as a service to airlines. Since both groups of customers have differing requirements, the design of the product should ideally incorporate both sets of requirements and meet the demands of the product and service customers. Different types of design may be required to meet these differing demands, meaning that the product-service transition can bring a need for new design capabilities.

A major challenge in developing product-service offerings is the ability to integrate the disparate elements, for example designing a product alongside an aftermarket solution. This requires internal and external mechanisms for integration. Multi-disciplinary design teams can be used to integrate the various functional requirements of development and help to introduce a design thinking approach to non-designers. Meanwhile customer-facing units are commonly proposed to integrate the requirements of multiple customers into design specifications and to offer an interface between customers and the product facing parts of a company. This research also identifies their value as a buffer, to limit the pressure from customers on those responsible for designing and developing product-service offerings.

This research suggests that the capabilities required to design products give a company an advantage which they can exploit by delivering services related to these products. It shows that required capabilities can be accessed through partnerships with other companies (chapter 5) and that manufacturing capabilities can be outsourced to enable a focus on services. Meanwhile, design capabilities, such as those related to advanced technologies, are likely to be closely guarded as they are seen to be the source of competitive advantage. The comparison with other studies in chapter 7, suggests that outsourcing manufacturing resources is a common part of a product-service transition (Davies et al., 2007), whereas offering services without the appropriate design capabilities has been found to end in failure (Benedettini and Neely, 2010).

8.4 Managerial implications

The study has clear implications for managers of manufacturing companies, with the intention of increasing service revenues or repositioning their offerings. In terms of the organisational structure, consideration should be given to establishing a customer facing unit with both technical co-ordination and customer relationship responsibilities. This can act as a buffer between the company and the customer(s) as well as an integrator to provide the product-facing parts of the company with information and design parameters. The design process itself must integrate the different areas of expertise, whether these are simply product and customer knowledge, as in Perfect Peach or highly specialised technical areas as in Aero-Engine Co.

For a manufacturing company, making a transition and developing product-service offerings can be seen to involve the following

Define Value

Define what customers want from the offerings, which entails understanding how they use the products they buy and which processes they would be willing to pay for, rather than do themselves. At the same time, consider what processes the company is capable of performing profitably. Defining value involves two parts, which must be considered simultaneously, so that one informs the other, rather than sequentially.

Customers

The company should be considered as one link in a long chain from raw material extraction to consumer or end user. To offer services, the company must determine which customer or customers will be targeted. This will be determined by the existing design capabilities and will in turn help to determine how the design capabilities should be re-aligned. It is important to understand these customers' processes as deeply as possible in order to develop offerings for them in future.

Capabilities

A successful manufacturer should have a design capability which represents a competitive advantage, for example the capability to design superior products or to work with advanced technology. This capability can be leveraged to provide the capability to manage the products in use and, hence, offer services. The company should determine what kind of design capabilities it possesses within the categories of product,

customer-facing and business-facing, and how these capabilities should be re-aligned to design for the chosen customers. Re-aligning the capabilities can involve training and developing design tools as in Aero-Engine Co. or simply hiring employees with the appropriate design skills as in Tiling House.

Design value

This involves designing the products, services and associated network of partners.

Design product platforms

A standard product should be developed, particularly in industries where product complexity and development lead times are considerably high. Ideally, this should take account of the requirements of multiple customers. These requirements can be identified through a combination of previous experience, for example by involving servicing personnel in design, customer relationships, through the customer-facing units, and condition monitoring, where the technology is available and is approved by customers.

Customise products

A standard product is developed, either for a customer who acts as an OEM, as is the case for airframers, or for sale to customers who wish to purchase a standard product. Customisation of the standard product, however, represents a service in itself, as well as allowing products to be adapted to improve the efficiency of a product-service offering.

Design the network of partners

It is likely that a company focusing on services will reduce its manufacturing costs by designing the offerings and outsourcing production. This will allow a focus on service delivery, customer relationships and technology development. If this is the case, the company must develop its capabilities in designing and co-ordinating networks of component manufacturers and other partners, to develop a complete product-service offering.

Deliver value

Delivering value involves integrating and managing all of the disparate elements of a product-service offering. The customer-facing unit is the front line in terms of managing customer interactions, but must co-ordinate service delivery, which in turn may require design and production involvement, for example re-designing components to improve the performance of products which are in use. Managing products, whether this involves servicing and maintaining them on a regular basis or operating them on behalf of the customer, requires capabilities which a manufacturer may not have traditionally possessed. The

ability to design products, however, should make the company capable of co-ordinating their management for customers in a mutually beneficial way. The company should also use this as an opportunity to gain increased knowledge, which should be fed back into the design process.

8.5 Generalisability

The problems associated with generalising the results of case studies were discussed in chapter 2. Large scale quantitative studies seek to achieve statistical generalisations, for example, if a random sample exhibits statistically significant behaviours on average, the same behaviours, on average, can be expected from the rest of the population. The case companies studied in this research have not been chosen for statistical reasons, or considered to represent an average. Instead they have been chosen with the objective of theoretical generalisation. The observed behaviours, therefore, cannot be directly generalised to any population, but lead to theoretical findings, which should be generalisable to some degree.

Methodological tools to improving reliability were described in chapter 2 and 3. Although subjectivity is a necessary part of any qualitative study, these tools were used to try to increase the value of the findings. In addition, the researcher sought to compare findings, particularly at preliminary stages in the research, with those of other researchers who studied either the same topics or the same companies. The publications list presented at the beginning of this thesis highlights this point, as does the literature review in chapter 7. The researcher presented preliminary findings at a number of conferences, where the findings could be peer reviewed and discussed with other researchers. This helped in the interpretation of results and the positioning of findings. The findings were compared with the literature to identify the unique contributions of this research within the context of previous studies. Chapter 7 demonstrates support for the findings from other sources, which adds to their generalisability.

8.6 Limitations

In this chapter and previous ones, reliability tests, comparisons with other researchers' work and other methods of improving the quality of this work were reported. Despite these attempts, limitations in the research are unavoidable and, with hindsight, some of these can be discussed here.

Definitions

The research set out to study the role of design, based on Roy and Riedel's (1997) understanding of the role of design in product success, as opposed to Perks et al's (2005) understanding of the role of design in companies. The former relates to the outcome of the design effort, for example whether it results in new features or aesthetic impact, whereas the latter is more descriptive of the function of designers, for example whether they contribute to or lead NPD. This difference of opinion highlighted the researcher's frustration throughout the research, with the use of the same or similar terms to mean different things, or the use of different terms to mean the same things. This is particularly apparent in chapter 5, where the terms 'servicization' and 'servitization' emerged from isolated bodies of literature. The use of the word 'organisation' (Pawar et al., 2009) caused confusion with reviewers and others, since it was used in an unfamiliar manner at times. Attempts to minimise such confusion have been made, but criticisms based on a difference of opinion regarding the word 'design' in particular remain.

Unit of measurement

Some researchers work with concepts which are well defined and easily measured. Unfortunately, the topics of interest to this researcher turned out to be ones whose definitions are the subjects of ongoing debate. This has contributed to a lack of precision in the measurement of variables. A working definition of design was adopted and an attempt was then made to classify and measure design activities. This researcher was not the first to find 'design' a difficult concept to measure. The research in chapter 4 contributed to the development of a survey seeking to measure design spending in a large sample of UK companies but was notable for a dramatic revision of the targeted sample size.

While others overcame this difficulty by using a narrow definition or a focus on a particular type of design, the researcher was keen to investigate silent design, despite being an incredibly challenging concept to investigate. The approach of discussing design activities within the framework shown in figure 8.2 was considered to be useful in exploring different types of silent design, from a number of different perspectives. A deliberate effort was made to interview people offering these different perspectives, as opposed to focusing on designers or engineers alone, whose insights would be limited. As discussed, the communication in Aero-Engine Co. is deliberately restricted, meaning that engineers have a lack of knowledge about customers and suppliers outside of their areas. Therefore those who manage the designers and particularly those with involvement in IPTs were considered useful interviewees.

Unit of analysis

In case study one, companies were investigated from a single perspective, by interviewing a key informant who held a senior position and could provide an overview of the company and its design activities. In case study two, this approach was supplemented with other available material on the companies, from presentations and documents. The size of the companies made it clear that a single perspective could only be useful in studying research with a very limited scope. In case study three, an attempt was made to access as many different perspectives as possible. The understanding of design

Access

Lack of access was an extremely frustrating factor in preventing research and restricting the researcher's ability to plan ahead. On at least three occasions, access was agreed in principle but eventually was not forthcoming. Firstly, during the collection of data at Aero-Engine Co. there was a discussion with one of the interviewees centred on gaining access to a team involved in a current or past project. This offered the opportunity to collect in depth data on design carried out by all of the different functions typically involved in a product development team. Additionally, there was a desire to collect secondary quantitative data in this context, which would open the possibilities for other types of analysis. The intention was to study at least one such team to enable extrapolation of results to the company as a whole. Unfortunately, the initial enthusiasm shown waned when the contact was no longer able to commit to the project. Similarly, contact was made with a small company which had expressed interest in making a product-service transition and had made contact with the university to invite academic involvement. Yet, despite email communication and repeated effort, contacts from the company were unavailable to pursue any interest further. On one occasion a visit was made to a company which offered an opportunity to study product-service offerings in a completely different industry to that of Aero-Engine Co. The meeting explored the company's offerings, their transition and design management and a case report was drafted as the beginning of a case study which was intended. Again, the initial interest of the company seemed to wane and another opportunity was missed.

Type of company

In chapter 5, the existing product-service literature was criticised for being too narrowly focused on case studies of large companies in the aerospace sector. This criticism could similarly be levelled at this research, where the Aero-Engine case study is a particularly large part. In defence, it could be argued

that the perspective taken is somewhat different to several other studies, since the focus is on design and particularly since a broad definition of design is used. Additionally, the findings were compared with those made from studying other companies and the findings of other researchers, to make a useful contribution to knowledge.

8.7 Further research questions

The findings of this research should be seen as a starting point for a deeper exploration of design in product-service organisations and in other types of companies.

Design capabilities

The term 'design capabilities' has been used in this chapter, although the research did not set out initially to study such capabilities. It is argued that Aero-Engine Co. has capabilities to design its products, which others cannot emulate, but does not have the type of customer-facing design capabilities which others might possess. It is also suggested that the company is reconfiguring its capabilities, for example by establishing supply chain design as a capability and by increasing its understanding of customers. Conceptually, this was related to the strategy literature, where dynamic capabilities describe a firm's ability to reconfigure its resources to cope with changing environments. Few studies have attempted to link design with the theory of dynamic capabilities. Danneels (2002) focused on product innovation, rather than design, while Azadegan et al (2008) have a rather confusing understanding of the theory. There is scope for a study of design as a dynamic capability or design capabilities as resources to be reconfigured by dynamic capabilities. Equally, there is an opportunity to study the reconfiguration of resources demanded by servitization. This researched has contributed in this area by identifying the interplay between design capabilities and servitization.

Design/customer interface

Much has been made of the so-called front/back structure and the role of customer-facing units as the single point of contact for customers. This approach was described here as a form of protection, shielding those designing products, from the customers. An alternative approach, observed in other companies is to give designers greater involvement. In Tiling House, as described in chapter 4, designers are employed as sales people. Some would argue that talking directly to customers gives the designer a better understanding than having the voice of the customer interpreted for them by others. It is clear that

there are two different approaches, having designers at the front or the back of the organisation. Both appear to be applied successfully in different companies. An interesting topic for the researcher is where these two approaches should be used.

Service culture – how deep?

Another topic concerning the customer-facing units is that of a service culture. Many would argue that a product-service transition demands everyone in the company become service oriented, or customer-centric. This research has presented an alternative viewpoint, advising caution to those prescribing radical change. Instead, the potential for customer-facing units and other approaches to minimising the amount of change required could be explored further. An alternative viewpoint could be that a service culture is not what manufacturers need, but rather 'design thinking' could be of value. Martin (2009) describes design thinking very much in terms of integrating between disparate elements, and this theme of integration also emerged from case study three. Further investigations of design thinking could focus specifically on its role in product-service organisations.

Customer experience design

Customer experience is a term used, not just among marketing researchers, but increasingly by service operations management scholars. For example Johnston sees the emotional outcomes of a service as a vital consideration for operations management (Johnston and Clark, 2005), while Chris Voss has published several articles on his studies of experience-centric services (Voss et al., 2008, Zomerdijk and Voss, 2009). While Johnston clearly sees the experience as a part of every service, Voss distinguishes between experiential and other services. In chapter 5, the latter view was more evident in the assertion that the customer experience is not a major concern for many large product-service organisations. Yet in chapter 6 and the discussion in chapter 7, there is a suggestion that even Aero-Engine Co. has made some small steps in this direction. And a more recent study has distinguished between different categories of experience and the benefits of adding some experiential elements, even to very functional services (Beltagui et al., 2010a). There is scope for further investigation linking the customer experience and product-service concepts. In particular, the assertion that design capabilities enable or restrict a product-service transition should be explored in such an investigation.

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Appendix
Design activities

This section presents a list of the design activities identified from the case study of Aero-Engine Co. as described in chapter 6. These activities were categorised according to the type of design, stage of product-service development and type of customer. A brief description of each activity is provided, along with a quotation from an interview, either in their own words or a paraphrased description.

Customer-facing design activities

Designing value (airlines)

"[the repair and overhaul facility has] a railway station inside the facility...you can't order every time a low bed shipping trailer so what you need to do is ship it by train...That is facility design but it is also customer facing design."	Planning R&O facilities, taking into account transport links, is a design activity since it requires identification, selection and generation of options and results in a plan for implementation.	NS (1)

Delivering value (airframers)

The design of some new facilities shows consideration of customer perceptions. A plant producing parts for out of production engines has been unchanged for years. Meanwhile a new assembly and test facility is regarded as exceptionally clean and technologically advanced. Visitors are likely to be shown the latter.	The visual appearance of an assembly and test facility shows signs of design to create an environment which is suitable for customer.	KL (1)

Delivering value (airlines)

"...there's been a kind of education that we've had to go through with the customers"	Creating reports and training for customers' pilots, is design because it involves analysing data from condition monitoring and creating a plan or procedure to be implemented	MK (1)
A problematic component was replaced on certain engines in service, under the assumption that a solution would be required by the time of the next scheduled shop visit.	Replacing faulty components requires a design activity to create an improved component design, overcoming the problem in the long term, while providing a temporary solution by creating a new maintenance schedule.	LH (1)

"...if something like this happens you normally end up buying more parts, getting into the shop earlier organising cover for airlines that are affected with this, managing the whole fleet. And it can be that you have mis-designed a part and it doesn't last as long as you wanted it or it can be that you have a manufacturing issue that somehow the part had been defective and had been put out here and you have to put the engine spec back in. "	Replacing faulty components on engines in service is design because it requires the creation of a short term solution and long term plan, including scheduling repair shop visits and specifying a new component.	PM (1)

Product design activities

Defining value (airframers)

Previously “some clever guys designed the engine and some factory had a go at making it”. Now the company is “getting better” through its use of DfM and by design and manufacturing personnel working together more closely. Now that the manufacture of products has become more global, the Supply Chain function is also required to work more closely with design and manufacture.	SCUs, including members of design and manufacturing teams, are involved in designing products and production processes.	AG (1)
Where parts are required to be replaced less often, their lifetime should be extended. This can be achieved by altering tolerances or the materials used for components.	Developing product-service offerings involves design	CJ (1)

Defining value (airlines)

"...we'll get a request to bid on a new airframe for example and it will have targets around the emissions, around noise, the weight, the fuel consumption... taking all of that in consideration determines the level of technology we'll have to put in the engine to make a step change from the previous one."	Responding to a request for proposal (RFQ) involves design since it requires the creation of a set of parameters to be met by the product.	AT (1)
The requirements specified now need to be reviewed, for example the trade-off between the time between overhauls and the engine’s fuel burn. A less efficient engine is acceptable if the cost to the company of reducing fuel efficiency is balanced by the saving on maintenance. Requirements require optimisation across the life time of the product, rather than performance in use alone.	Specifying requirements with respect to product-service involves design to create an optimum configuration.	DK (2)

"...they were talking about some issues in the later stages where they haven't got enough holes on the casing to carry out a boroscope study on wing. At the product design stage, the design for service community should pick that up or they should make alternative arrangements for repairs at future shop visits. Not every time it is possible to get rid of these things. The emphasis is on reducing the weight at the moment."	Design for service workshops involve creating proposals for service related improvements to components and products.	GS (1)
"...I would say that the systems engineering is design. I want a fan this big, I want a compressor this big with so much airflow, so much compression ratio, I want a turbine this big."	Specifying system requirements is a design activity since it involves creating a plan for an overall system which integrates all of the necessary technical specifications	MH (1)
"...there are a lot of decision meetings before you are starting with development...in this stage they are at first planning the purpose of what we want to achieve. Then you go through several aggregation steps during engineering drawing, safety issues and everything. And you go into this loop again and again and again to achieve what you have in this stage, your 'vision' of the product."	Developing a product vision is a design activitiy since it involves the iterative creation of an overall plan for the product.	NS (2)

Designing value (airframers)

"There's more novel design features in [shafts, rather than novel technologies]. We have particularly thin sections that are designed to flex, so that's a design thing."	Producing some (non-critical or complex) components requires design to create a shape which offers the required physical properties.	CM (1)
"the strategic research centres… are at the cutting edge of design".	Developing technologies, products and materials for future use involves design.	DK (1)
New products need to be designed for maintenance, which includes making components more accessible for repair and also can involve modularisation, to make it easier to replace individual components. The aim for new products is to make detection and repair of faults easier, faster and cheaper... Using a boroscope allows faults to be diagnosed without removing the engine from the wing of an aircraft, like conducting keyhole surgery on an engine. There are cost and time savings if repairs can also be conducted in situ.	Developing product-service offerings involves design to facilitate maintenance.	KL (3)

"...[the product-service transition] has certainly put pressure on the designers in the Supply Chains, to design much more robust components. We're much more focused on lifing now, and I think we'll start to see that more and more. We're starting to have conversations about process monitoring and how we can improve component life."	Producing product-service offerings involves design to create more robust and longer lasting components.	MK (2)
"...if something like a turbine blade was designed over here, you don't have one designer doing it. There are 3, 4, 5 designers, there are the stress specialists, the material guys that look after the technology. You have to get the air system designers in there...Its basically the work of a few hundred people."	Producing components involves analysis by several experts each of which is designing some aspect of the component.	PM (2)

Designing value (airlines)

Airlines make different demands on their engines, for example, they may favour steep or shallow ascents. This means that products require customised design to meet these specific requirements.	Customising products to ensure performance for specific usage requirements involves creating a new configuration or specification to be produced.	KL (2)

Delivering value (airlines)

The service transition means more engines in the end of life phase must be supported. This means maintaining support for engines until there are “only two or three” in service before withdrawing services.	Supporting engines in end of life involves design because it demands out of production parts to be reproduced, often demanding re-design	AG (2)

"...we took new technology that was at the time, best on fuel, best on emissions, and put it into an old product... the other example is where we've released what we call an EP kit, which replaces quite a bit of the turbo machinery, again for fuel burn. Its not that the product wasn't performing, its just that market pressures have become very focused recently, over the past two or three years, on fuel and customers have said, its quite a big fleet we've got, we'd like you to do something about fuel. So we went out and launched a development activity that said here's some real improvements in technology..."	Maintaining engines in service involves creating new components to improve performance.	MK (3)
"...our calculations [on a component designed 20 years ago] have been proven to be wrong in that specific temperature range and that nobody had the experience of the material they used. They simply have exceeded the limits of the knowledge at that time...If we design something new here this is state of the art in terms of technology."	Producing components for "legacy" products involves design to create new production plans.	PW (1)

Business-facing design activities

Defining value (airframers)

"its normally the supplier that owns the packaging. We won't design it, we have a company that we use to design any re-usable packaging, we'll use them and we'll work with them. So the supply chain designer will very much just give them the information and make sure that everything's progressing"	Producing re-usable packaging, according to specifications is a design activity carried out by a supplier.	AT (3)
we design our capability acquisition process, we follow the MCRL process – Manufacturing Capability Readiness Level – we do manage technology that way. So if someone came up with something novel, we'd say "I'd have to find a supplier who does that, we'd have to invest in that technology"	Suppliers are managed using a design process related to the technologies and capabilities they posses. Their acquisition was described as a design activity.	CM (6)

Designing value (airframers)

"...a development engineer to work out what engines it goes in, because once we deliver a set of hardware he'll say "that's for engine 4, but I can use that same hardware in engine 7", otherwise he'll have to order more for us, it'll take longer and cost more money, so you've got those type of people."	Identifying common components is a design activity since it involves creating a plan to match technical requirements with shared components.	CM (2)
"I've got numerous MEs involved, for me to do one shaft is about two and a half thousand hours of effort...that probably involves seven or eight manufacturing engineers, someone with special skill in NC programming, CMM programming, somebody to do the geometry, someone to do the tooling design, i'll get to seven or eight people who touch it."	Putting components into production requires design to plan manufacturing and program the machines which carry it out.	CM (3)

"we work with the designers as the design evolves to design the method of manufacture, as the supply chain designers will then take that evolving design and design a supply chain which one day didn't have a coating supplier and the next day because the design has changed they have to change the supply chain to accommodate those kind of things."	Manufacturing processes and supply chains are re-designed following updates to product designs.	CM (4)
"we introduce a sealed method to the rest of the factory... how we make sure we're doing it ABCD is we have the template that says that's the way we make the part, we argue with design to make it fit that process and if there's exceptions, we flag it up that this part is going to have to go back through the factory and be inspected again, are we happy with that? Are we going to have to buy a new machine?	Manufacturing processes are designed to meet the optimal flow for the factory where production will occur.	CM (5)
Innovative products are designed to meet the requirements set by customers and airframe manufacturers. Manufacturing processes, however, make these products possible and are also a source of innovation.	Developing innovative manufacturing processes is a design activity since it involves creating plans to enable production.	KL (4)
Design of the supply chain has not always been considered important, but recently the formal role of supply chain designer has been created in the company. It is now recognised that without such a role, programmes are less likely to be profitable. As product designers do, they ensure that the supply chain is fit for its purpose and operates at an acceptable cost. Modelling tools are used to predict where parts will be needed and maintain the performance of the supply chain.	Supply chain design involves modelling and simulation and aims to ensure specifications are met by the output of the design.	KL (5)
When a new engine is developed, they are required to understand it and the differences between it and previous versions, in order to develop a maintenance plan.	Developing repair schedules is a design activity since it requires the creation of a plan for the maintenance of a new product.	LH (2)

"I would not underestimate the sheer effort that goes into keeping a whole programme integrated. That I think is part of the design."	Programme management is a design activity since it involves iterative planning to integrate activities throughout the design process.	MH (3)
Multiple supply chains are designed throughout the lifecycle of an engine. During the production phase, there may be a smaller number of suppliers, but this is increased when ramping up production.	Managing projects involves designing and re-designing supply chains, using more or less suppliers at different stages of the project.	MK (4)
"[the person responsible for identifying the site for a new facility] spent a year going around measuring bridges. Railway bridges and highway bridges because before you make one hole in the ground and dig it out you need to be 100% sure that you'll get a project and you'll get the product into your facility. if you want to maintain or overhaul these types of engines later on in your facility then you need to make sure that these products reach the facility, by highway, by lorry, however."	Planning facilities involves design of transport links.	NS (3)
"[the largest component of a newly developed model of engine] is bigger than a normal sea freight container so you cant transport this engine with anything except a low bed loader. That is one issue you need to think about."	Planning transportation involves design to consider dimensions and requirements of components.	NS (4)
"In the rig business or the test business... you need to look to the design and you need failure investigations and so on, you need to follow the design processes."	Test rigs require design to plan a configuration based on product design.	PM (3)
"the [product] design is fixed I cannot change it, but the problem was how can we get these parts onto the flow line. Can it it be done? Yes it can be done, it took us some time but we managed it."	Producing unusually designed components requires design to create new tooling.	RM (1)
"what we are programming for our CNC controlled machines is not content of the engineering drawing... as we take the CAD geometries to manufacturing and the manufacturing engineer makes stage drawings, the NC programmer makes, a 'tape' and even these programmes don't comply to the stage drawings because we 'fiddle around' on the diaphragm – yes, two or three hundred microns that way or that only to comply, when its finished, with the drawing."	Programming machines requires design to create modified plans, resulting in the process to match production drawings.	RM (2)

Designing value (airlines)

Purchasing is an important part of the development programme. Getting data for quotes is the foundation of designing the supply chain. The purchasing strategy might be to develop competition between suppliers or perhaps to give more responsibility to a small number of suppliers.	Developing a purchasing strategy is design since it involves creating a plan incorporating suppliers and a desired relationship.	AB (1)
The Supply Chain and Aftermarket solution are re-designed throughout the lifecycle of an engine, as it moves from volume production through to its “stranger and alien” phase. The ‘commodity strategy’ differs at each phase, from a low cost, lean manufacturing approach for volume production, to flexibility and a different skill set for stranger and alien.	Managing the supply chain involves design and re-design to create new plans throughout phases of a product's lifecycle.	AG (2)
"we've got this new role called supply chain designer and the intent of that role is for us to design the supply chains from raw material out the ground... so the whole value stream from raw material out the ground to parts delivered...and then it would be up to the CFBU, the Customer Facing Business Unit, to manage the part from there."	Supply chain design is a design activity since it involves the creation of a plan for moving material between suppliers and factories.	AT (2)
"what we tended to do was design it based on a number of things so hows this process going to work, how is the manning going to work, what is the infrastructure like, how are the production systems going to work? So we took the approach of man, method, machine, material and when you're talking about this particular part of the process, what are the implication on each of these?"	Developing production facilities involves design to account for the relevant activities to be conducted.	MB (1)
"we found there was a lot of excess material lying around that was consolidated into one area, you have to take a hit and get rid of that. There was a lot of re-engineering done, its this process its got to go there. And within the existing footprint we tried to pilot it to see how it will look like. We did away with 20 carousel units... we got down to about 3 in production and 5 in spares. it had built up over the years when it was a huge amount of stock and in a different environment."	Managing existing facilities involves design to create layouts and arrangements that make better use of space.	MB (2)

"we tried to set up the factory in line with the current state of the art so we try to keep flow lines and avoid going backwards and forwards within this area of the business. We try to put in-service process inspection, in line with the process. Allocation of parts to machines and machines feeding each other, this review has taken place... With a a dramatic change in strategy then of course we would review the factory layout but its not that the factory is designed to be layout-wise flexible."	Production facilities are designed to maximise output of specific components.	PN (1)
"...we want people to get excited about doing the same job every day to a high level of efficiency."	Factories are designed to maximise output of specific components.	PN (2)