STRATEGIC INNOVATION NETWORKS

MARTIN JOHN JAMES BECKINSALE B.Sc., M.Sc.

Doctor of Philosophy

ASTON UNIVERSITY

Re-submitted March 2001

Aston University

STRATEGIC INNOVATION NETWORKS

Martin John James Beckinsale

Doctor of Philosophy
March 2001

THESIS SUMMARY

This thesis draws on two key areas of the innovation literature, the strategic management of technology (SMOT) and innovation networks. The aim is to integrate these two areas of the management of innovation literature to develop a framework which I describe as the Strategic Innovation Network (SIN). The key proposition that the revised framework (SIN) aims to address is based on the work of Chandler (1962). Chandler's (1962) conclusion that 'structure follows strategy' is examined in relation to the interaction between corporate/technology strategy and network structure. The SIN is intended to address weaknesses in both the SMOT and network literature.

The research data is based on five detailed longitudinal case studies. The organisations are defined as mid-corporate firms operating in traditional manufacturing sectors. Each organisation was chosen on the basis that it was aiming to develop its innovative capacity through product or process innovation projects. The research was carried out over an 18 month period with interviews being held regularly to develop the longitudinal aspect of the study analysis. The data for each individual case study is examined using the SIN framework.

The longitudinal approach addresses the objective to provide a dynamic model of the innovation processes by mapping the changes in network structure during the course of individual projects. The network structural changes are examined in relation to each organisation's strategy and five key dynamic network stages are identified in relation to the innovation process. These network stages show the influence strategy has on the structures adopted by the five case studies.

Keywords

Technology strategy; strategic management; dynamic innovation process; dyadic links; and network actors.

ACKNOWLEDGEMENTS

I would firstly like to thank my supervisor, Dr. Oswald Jones, for his belief and all his time and effort. I do not think I could have asked for a more committed supervisor. I am also grateful to the Strategic Management Group at Aston University for allowing me to make a contribution to strategic management thinking. Thank you to Dr. Steve Conway who in the early days of the thesis gave me a great deal of needed encouragement.

The research strategy utilised in the thesis was reliant on a number of actors within organisations. I would like to acknowledge David Smith & Graham Kennet (OCL), Peter Morris & Andrian Parker (SUA), Mike Burnell (DDL), Gareth Williams (DFM) and Gary Stevens (WEL) plus all of those individuals who gave their time to be interviewed and made this study possible.

I would also like to thank my parents for their support especially over the last few months of the thesis. And finally, Sonya. Thank you for your understanding and support. Love you!

CONTENTS

CHAPTER 3 NETWORKS

CHAPTER 4 CONCEPT INTEGRATION

CHAPTER 7 INNOVATION: SUA AND DFM

LIST OF TABLES

LIST OF FIGURES

Chapter 1: INTRODUCTION

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

In the following thesis a conceptual framework described as a 'strategic innovation network' or SIN is utilised as a means of examining technological change in mature manufacturing firms. I begin by examining existing literature associated with the management of innovation. In defining the nature of innovation management my intention is to address significant limitations of the existing literature. Innovation is a crucial source of competitive advantage (Tushman et. al, 1997) whether incremental or radical (Drejer, 1996). Through new product development, innovation can provide an organisation with the means to redress itself in current and potential markets rather than trying to sustain itself through cost reduction and downsizing. The following question underpins the management of innovation literature (Burns and Stalker, 1961): how do organisations manage innovation to create and sustain competitive advantage?

The management of innovation has been studied from a variety of perspectives over the past three decades. These include the resource-based view of innovation (Foss, 1997); the strategic management of technology - SMOT (Dussauge et. al., 1987; Drejer, 1996); knowledge management (Scarbrough, 1999; Swan, 1996); and the strategic innovation process (Afuah, 1998). An increasingly significant feature of the literature is the importance of formal and informal networks. In influencing the success and failure of innovation, networks are seen to play an important role (Rothwell, 1994; Tidd et al., 1997). Since Chandler's (1962) key contribution many writers have attempted to identify the best structure for successful innovation (Afuah, 1998). The results of work by writers such as Steele (1989) has provided a deeper understanding of organisational structure. The strategic management of technology literature identifies a range of organisational structures including: skunkworks, matrix, and independent business units (Dussauge et al, 1987). Although such structures are important the SMOT literature has made limited use of the network literature. The management of innovation literature has developed networking elements including inter and intra organisation networks as well as entrepreneurial networks (see Allen, 1971 & 1977; Autio, 1990 & 1997;

Oliver and Ebers, 1998). However, as this literature has developed, the SMOT school (Drejer, 1996) appears to have done little to integrate the networking literature. The SMOT literature has concentrated on researching particular network structures (strategic alliances and joint ventures). These structures are generally based on relationships between divisions and departments and the importance of key individuals such as product champions (Pearson, 1992) and boundary spanners (Swan, 1996). Many formal and informal linkages made up of diverse sets of actors are required to meet objectives during the innovation process. The question, therefore, is in what way can individual actors in the innovation process be identified and analysed?

It is now widely accepted that innovation management should have a strategic focus (Dussauge et al, 1987; Twiss, 1992; Tushman et. al, 1997) but the SMOT literature lacks a detailed network perspective. I expect to raise further significant limitations of the literature relating to the innovation process and its network perspective at the technology and strategy level. One such limitation is the lack of research into Small and Medium-sized Enterprises (Dodgson and Rothwell, 1991) and the concentration of the innovation literature on large firms and high-technology based firms.

1.1 MANAGING INNOVATION IN SMEs

The management of innovation literature has concentrated on advantages of large high-technology firms rather than small or mid-corporate firms. The innovatory advantages of large firms are in the main associated with their relatively greater financial and technological resources whereas small firm advantages are those of entrepreneurial dynamism and internal flexibility. However, as stated by Hoffman et al. (1998: 39) *'the actual processes whereby small firms undertake innovative activity remains unclear'*. What is clear is that SMEs do not necessarily innovate in formally recognised ways. Differences between small and large firms include: limited commitment to R&D; limited resources and skills given the considerable demands required to identify and assess important new technologies; reluctance to provide staff with time to harness technology and difficulties in managing technology strategically; difficulties in accessing external capital for growth; lack of awareness of government innovation schemes; and power imbalance in collaborating with larger firms (Rothwell, 1989; Dodgson, 1993; Hobday, 1994; Jones and Smith, 1997). As the literature shows (Rothwell and Dodgson, 1994; Thomas and Jones, 1999) innovation in SMEs also varies significantly from sector to sector. In sectors such as aerospace, motor vehicles, dyes and shipbuilding innovation share is small compared to specialist machinery and bio-technology. A significant sector is manufacturing (Thomas and Jones, 1999 - DTI Study): where over 49% of firms employ less than 250 people; accounting for some 4.5 million jobs; and having 48% (in 1998) of small firms innovating. It is this sector that interests me in terms of the thesis study given the economic value it has for the UK economy and the increasing pressure such firms and the sector is under.

1.2 THE THESIS

The key proposition upon which the thesis is based relates to Chandler's (1962) conclusion that 'structure follows strategy'. I intend to examine the interaction between corporate/technology strategy and network structure. This will be achieved through integrating the SMOT and network literatures. The aim is to develop a framework that incorporates key elements of both. In doing this the thesis will provide the SMOT literature with a network perspective, address literature weaknesses and ultimately utilise the SIN framework to examine a set of questions/propositions. These propositions should lead to an understanding of the relationship between strategy and network structure and guide the analysis. By examining the management of innovation in mid-corporate firms the framework can address the problem of the literature concentrating on large firms. Organisations included in the study must be aiming to develop their innovative capacity through product or process innovation. Projects and network actors will be identified in such organisations so that the network relationships can be mapped. The mapping and analysis will be carried out over a significant period of time to monitor structural change as well as strategic decision-making. Taking a longitudinal approach to the research analysis will also provide a dynamic understanding of the innovation process.

1.3 THE THESIS STRUCTURE

I adopt an approach that integrates a network perspective with the strategic management of technology literature as identified above. My objective is to utilise the conceptual framework as a means of examining the innovation process in medium-sized manufacturing firms.

Chapter 2: This chapter reviews the SMOT literature and identifies current network perspectives and failings in this area. The chapter starts with the historical development of strategic management through to the identification of current weaknesses and limitations. I also define technology, innovation, invention and distinguish between types of strategies that underpin strategic management theory. The chapter concludes with an examination of the limited network perspective in the SMOT literature and discusses Dodgson and Rothwell's (1991) framework that may have value in developing a network perspective.

Chapter 3: In Chapter 3 I review the network literature including definitions, functions, types and orientation. As in Chapter 2, the limitations are discussed showing that firm size is a key weakness with few studies of smaller firms. Finally, I look at the way in which networks can be studied and identify a framework used to reveal and map-out the set of actors, transactions, relationships in the development of discrete innovations.

Chapter 4: In this chapter I integrate the two conceptual frameworks identified in Chapters 2 and 3. This is achieved by examining the variables and the underlying concepts of the two approaches. A network template and set of mapping conventions are developed in what I describe as the Strategic Innovation Network (SIN).

Chapter 5: The methodological approach to the research is defined. The research strategy is developed on the basis of questions and propositions raised in the literature review. The propositions and the strategic innovation network (SIN) framework aid in structuring the research strategy. A case study approach is utilised to examine the main proposition which is that corporate/technology strategy influences the network structure associated with a particular innovation.

Chapter 6: Five cases are introduced by providing general company details as well as briefly introducing each innovation project. The organisations are placed in the context of medium-sized (mid-corporate) manufacturing firms. DTI statistics on the current number, size and value to the UK economy are also provided.

Chapter 7: In the main analysis chapter I present two cases. The reason for their inclusion at this stage is the distinct differences between the innovation projects identified in each firm. The first is examined in relation to a product innovation project and the second in relation to a process innovation project. As the cases develop key networks are mapped and analysed using the SIN framework.

Chapter 8: I analyse the three remaining cases in this chapter. The analysis undertaken is exactly the same as in chapter 7. However, the three cases involve different innovation approaches compared to the main two cases. Hence, the supplementary cases help provide a richer understanding of the innovation process.

Chapter 9: I discuss the research results obtained by using the SIN framework with the aim of developing a dynamic view of the innovation process from a strategic network perspective. Results include: strategy influencing network structure, network orientation varying during the innovation process, and product and process innovations affecting the network orientation. I also identify five key network stages that form the basis of the dynamic innovation process.

Chapter 10: Summarises the thesis concluding with: the results, the main contributions, the limitations and possible future research.

Chapter 2:
THE STRATEGIC MANAGEMENT OF TECHNOLOGY

CHAPTER 2

STRATEGIC MANAGEMENT OF TECHNOLOGY

2.0 INTRODUCTION

The Strategic Management of Technology (SMOT) literature is concerned with incorporating decisions about technology into the long-term planning process. The aim is to provide management with the tools to identify technological issues that may affect the organisation. These tools enable managers to integrate technology into corporate and business strategies of the organisation. The overall goal is to increase the capacity for competitive advantage and innovation (Dussauge et al, 1987; Coombs et al, 1987).

Since the early 1980s the rate of technological change has intensified competition in a range of sectors (Coombs et al, 1996). Rapid product life cycles have led to a growing emphasis on time-based strategies. Increasing R&D costs, skill requirements, flexibility and diversity (see Freeman, 1991; Berry and Taggart, 1994; Coombs et al, 1996) have increased intra-firm and inter-firm integration and networking. It has become vital for managers to understand how they can create and maintain competitive advantage. Managers must position their products in the most profitable market segments and focus on building internal competencies and technologies so that the firm may invent and innovate better than its competitors (Prahalad, 1993). Therefore, technology is recognised as an essential element in a firm's competitiveness and a major feature to be addressed by strategic management. This has led to increasing empirical and theoretical research in the areas of technology strategy and strategic management (Dussauge et al, 1987; Porter, 1990, Dodgson and Rothwell, 1991 & 1994; Coombs et al, 1996; Ford and Thomas, 1997). The strategic management of technology perspective emphasises the acquisition, development and exploitation of technology and analysis of the organisation's knowledge, assets and capabilities.

The SMOT literature has over the past 15 years recognised that many companies are now developing innovative forms of decentralised networking by which knowledge may be produced jointly and shared (see Freeman, 1991; DeBresson and Amesse, 1991; Coombs et al, 1996; Ford and Thomas, 1997). Networks play an important role in bringing together clients, suppliers and companies with complementary assets to manage technology (Ford and Thomas, 1997). Within the SMOT literature network theory is incorporated through concepts such as collaborations and strategic alliances. These have been viewed as two of the most striking recent developments in industrial organisation (Dussauge et al, 1987). They are seen as a means of sharing knowledge and technology, but can also help to develop core competencies (Prahalad and Hamel, 1990); focus on demand; help access markets; and reduce the risks and uncertainty of R&D by spreading costs between the parties (Forrest and Martin, 1992). Recent literature has attempted to integrate the network approach with SMOT. Papers by Ford and Thomas (1997) and Gulati (1998) have made steps to link strategic management of technology concepts with networking therefore we are beginning to see the integration of two important theoretical perspectives.

The objective of this chapter is to familiarise the reader with the strategic management of technology including its development from the R&D management literature. This leads to an analysis of the following key aspect of the literature: the acquisition of technology for innovative purposes. The aim is to identify the ways in which this may be achieved and to identify the theoretical ways in which these have been researched. I aim to show that the specific SMOT literature (e.g. Dussauge et al, 1987) and the developing literature (e.g. Gulati, 1998) has a limited network understanding. In doing so I intend to identify particular frameworks or theories that may assists in developing the network perspective of the SMOT literature.

The chapter is structured to achieve the objectives set out above. Initially, I examine the strategic management literature and its historical development. This examination and discussion leads to the inclusion of technology as a strategic resource. A second key element is the understanding of the relationship between strategy and technology and for the purposes of this thesis corporate and technology strategy. As with the strategic management discussion I raise and discuss particular models of innovation (Rothwell, 1994) to support the value of networking in the innovation and strategic management process in the current global market environment. I then address the network perspective of SMOT in its current form as identified by the likes of Dussauge et al (1987) and developing research papers (Gulati, 1998; Ford & Thomas, 1997). I identify strengths and weaknesses of this network perspective. Finally, I identify a framework developed by Dodgson and Rothwell (1991) which I argue may provide a means to address some of the limitations identified.

2.1 STRATEGIC MANAGEMENT

The SMOT literature provides different ways of thinking about strategic management in relation to technology and innovation. Strategic management theoretical perspectives are well documented (Asch & Bowman, 1989; Zahra, et al., 1994) and concepts such as 'content' and 'process' capture the different ways of thinking about strategic management (Quinn, 1989). Content is the static issue of what strategy is supposed to be, while process is the dynamic element of how to achieve goals. Strategic management is the process of making and implementing strategic decisions. The task of strategic management involves both top management and managers at lower levels in the organisation. Strategic management: should involve and impact on all parts of the organisation (Coombs et al, 1987); concerns the scope of an organisation's activities; is concerned with matching the organisation to its environment; and is linked with capabilities and resources. Strategic management provides organisational decision-makers with the challenge to guide the future direction of the organisation. Key is understanding the complexity deriving from the requirement to adopt a strategic perspective, as opposed to a functional, specialist or technical view, and to understand and appreciate the subtlety, inconsistency, bureaucracy, political and imperatives of the world in which the organisation operates.

According to Asch & Bowman (1989: 40) there are a number of models to account for the process of strategic management (Chaffee, 1985; Mintzberg, 1973; Quinn, 1980; Peters and Waterman, 1982; Fredrickson, 1983). Chaffee (1985) proposes three generic categories: first is a 'linear' model which includes Mintzberg's (1973) planning model, second is Quinn's (1980) 'rational' model, and third is Fredrickson's (1983) 'synoptic' model. These models of strategy-making assume a progressive series of steps that include goal setting, analysis, evaluation, selection and the planning of implementation to achieve an optimal long-term direction for the organisation (Johnson, 1989). The 'adaptive' model is also discussed by Chaffee (1985) and Mintzberg (1973) and is based on the idea of incremental strategic change.

> *'The most effective strategies of major enterprises tend to emerge step by step from an iterative process in which the organisation probes the future, experiments, and learns from a series of incremental commitments rather than through global formulations of total strategies. Good managers are aware of this process. And they constantly intervene in it'* (Quinn, 1978: 9).

The interpretative model is rooted in the beliefs and assumptions that managers hold, via their cognitive maps. The model helps interpret the challenges the organisation faces and provide appropriate responses. These organisational beliefs and assumptions have been referred to in the management literature as 'paradigms' (Sheldon, 1980; Puffier, 1981; Johnson, 1987), as 'interpretative schemes' (Bartunek, 1984) and 'ideational culture' (Schein, 1985; Sathe, 1985). These models show that strategy formulation can be both a rational and logical process which is accounted for through the planning or adaptive mode. The interpretative model clearly links the decision making process to management. However, ultimately whichever model is undertaken it will be decision-makers and senior management that will formulate strategy.

The models embrace two broad views on strategy formulation. On the one hand strategy is a rational and logical process where managers are proactive formulators whilst on the other strategy formulation is an organisation process involving political, cognitive and/or symbolic aspects of management. Quinn (1989) points out that the management process is a conscious one and should be proactive but tends to move forward on the basis of incremental change. The literature suggests that management's role is critical to the strategic process. Quinn (1989) identifies a number of key roles in the strategic management process:

- to improve the quality of information utilised in corporate strategic decisions
- to cope with varying lead times, pacing parameters, and sequencing needs of the 'subsystems'
- to deal with personal resistance and political pressure any important strategic change encounters
- to build the organisational awareness, understanding, and psychological commitment needed for effective implementation;
- to decrease the uncertainty surrounding such decisions by allowing for interactive learning between the enterprise and its various impinging environments

- to improve the quality of the strategic decisions themselves by: systematically involving those with most specific knowledge; obtaining the participation of those who must carry out the decisions
- to avoid premature momentum or closure which could lead the decision in improper directions

Whittington (1993) provides a classification of the strategic management literature (Figure 2.1).

Aston University

Illustration removed for copyright restrictions

Figure 2.1: Generic Perspectives on Strategy (Whittington, 1993)

Classical theory can be traced back to the 18th century Scottish economics and the militaristic principles of Ancient Greece (see Bracker, 1980). The classical approach emerged in the 1960s based on profit maximisation through work by Ansoff (1965), Chandler (1962) and Sloan (1963). Evolutionary theory is based on optimisation rather than profit maximisation. It is argued that the market selects the stronger firms while the weaker or less competitive ones go out of business. Firms survive by experimenting with different initiatives and seeing which flourish and which fail. Processual theory is sceptical of rational decision-making and places much less emphasis on profit maximisation. The strategy is based on implementation, exploiting imperfect markets to build distinctive competencies, cultivating flexibility for incremental adaption. Systemic theory or strategy still views the decision-making of managers as based on rational analysis. Profit maximisation is given little weight due to the social networks weakening the possibility of individuals behaving in a rational economic manner. The approach sees economic activity embedded in a complex network of social relations

(Granovetter, 1985). The systemic view goes beyond the bounded rationality and micro-politics of the processual view and extends to various groups, interests and resources of the surrounding context. This strategy challenges other models as the objectives and modes of decision-making depend on the social characteristics and social context in which the strategy decision-makers operate. Strategy is concerned with exploiting, developing and sustaining the sum total of the organisation's knowledge, assets and capabilities (see Whittington, 1993).

As stated in the first paragraph of this section, resources are also important to the strategic management of an organisation. The resource based view of strategic management (Barney, 1986; Amit and Schoemaker, 1993) examines capabilities of firms that enable them to generate above normal rates of return and a sustainable competitive advantage (Oliver, 1997: 697). The resource based approach focuses on the characteristics of resources and the strategic markets from which they are obtained in order to sustain competitive advantage. A resource is anything which could be thought of as a strength of a given firm or more formally as those tangible or intangible assets which are tied semi-permanently to the firm (Wernerfelt, 1984). Resource selection in the literature is proposed on the basis of intra-firm decision making and external strategic factors. *'Sustainable competitive advantage is seen as an outcome of discretionary rational managerial choices, selective resource accumulation and deployment, strategic industry factors, and market imperfections'* (Oliver, 1997: 699). External factors include buyer and supplier power, intensity of competition; industry and product market structure. Such factors influence how and what resources are selected and then deployed. Such an approach at the very least complements the systemic theory/strategy in terms of a rational analysis. However, like the previous strategies it does not examine the social context, firm traditions, network ties, regulatory pressures and how these might affect and account for firm differences.

In this section I have discussed the approaches to the theory of strategic management and shown their value in understanding strategic management within firms (see Jones and Tang, 1996a). However, none of the approaches specifically consider technology as a competitive and strategic factor. Although, the resource based view has taken some steps in this direction. These approaches have tended to ground the strategic management of technology literature (see Coombs et al., 1987) rather than provide considered insights into the management of technology. Before I look more closely at the strategic management of technology the following section highlights the historical development of technology in the literature.

2.2 DEFINING TECHNOLOGY

To understand the strategic management of technology (SMOT) I begin by defining the term technology. Technology has been interpreted broadly (Dussauge et al, 1987; Gille, 1978) and over-used to the extent that technologies and techniques have become interchangeable terms. Defining technology also aids understanding of the terms invention and innovation.

2.2.1 Technology

The literature suggests that technology can be viewed in a number of ways. Drejer (1996) and Dussauge et al. (1987) posit that there are three particular approaches to defining technology: allusive, extensive and specific. Allusive technology is described as a key factor of success including market share and product quality. Extensive technology is defined (see Little, 1981 and Steele, 1989) as the application of knowledge. Technologies advance capabilities and can provide a firm with competitive advantage (Morin, 1985). Specific definitions are far more restrictive than the previous two as they link aspects such as science, technology and products to define the technology. An example of an extensive definition is Galbraith (1974: 31) who points out that *'technology is often viewed as the industrial application of science and as the understanding of this process'*. This view of technology however attributes the impact of technology to the industrial level. Technologies can be combined to create new advantages that might not have been available with individual technologies and are very unlikely to be confined to one application, business or industry. The majority of technologies are applicable to several business and industries. Braun (1998) argues that definitions should not constrain nor be too general in relation to technology. An example being specific definitions that can be broad in the sense that they define technology in relation to scientific or organised knowledge being applied to practical tasks. A good example is:

> *'A process which, through an explicit or implicit phase of research and development (the application of scientific knowledge), allows for commercial production of goods or services'* (Dussauge et al, 1987: 13).

Dussauge et al's (1987) definition assumes that technology develops from research and development but technology is not simply a derivative of R&D. The SMOT literature, as I discuss later in this chapter, provides numerous ways to develop and access technology. Braun's (1998) definition of technology is more closely aligned to that adopted in this thesis. Technology in Braun's (1998) definition places it within the innovation process and suggests that the innovation process is dynamic and occurs at a number of levels. He gives technology a 'hard' and 'soft' perspective with artefacts being the hardware and knowledge being the software. This is also supported by Monck et al's (1988) definition.

> '*.......the ways and means by which humans produce purposeful material artefacts and effects* or *........the material artefacts used to achieve some practical human purpose and the knowledge needed to produce and operate such artefacts*' (Braun, 1998: 8).

Braun (1998) defines technology in relation to individuals rather than groups or organisations. The definition does not specifically distinguish between product or process innovations as a result of the application of technology and is vague regarding what is meant by '*purposeful material artefacts*'. The technology literature (Coombs, 1987) shows that it does affect economic growth and raises the issue of innovation. The basis for the majority of definitions is that technology can be used or applied to provide a commercial product that the market can sustain. The definitions discussed above are valuable in particular contexts. Galbraith's (1974) definition, for instance, relates strongly to the impact technology can have on industries (creating new industries, altering industries and even the demise of industries). The industrial context is not an issue that concerns this researcher for the purposes of the thesis. Rather, the definition should be in the context of the organisation as the innovating unit. For this thesis, the definition of technology must take into account all three approaches (allusive, extensive and specific) as the research will examine technology for the purposes of competitiveness, growth and how knowledge is used and where it comes from. Technology will be viewed as a means of addressing a particular product, process or manufacturing need within a business. Also relevant is the practical application of science and knowledge to achieve products and processes that provide competitive advantage in current as well as new markets. Part of that economic goal must be the production of material objects for commercial purposes or the development of processes to enhance services. The definition that encompasses how I view technology in relation to the thesis is that set out by Loveridge and Pitt (1990):

> *'technology is used in the sense of a practical application of scientific or engineering knowledge. A technological innovation is then any product launched by the*

organisation, or any process introduced in production, for which the innovating unit had to familiarise itself with one or more new technologies, or with a new combination of existing technologies' (Loveridge and Pitt, 1990: 40).

2.2.2 Invention and Innovation

Innovation and especially technological innovation needs to be distinguished from invention. Invention is seen as a technical phenomenon involving the discovery of some new principle. Invention comes before innovation and plays a role in the science process through fundamental research and applied research as well as through entrepreneurs (inventors). Unlike an invention, innovation is an economic phenomenon involving the commercial use of new products or processes (it is invention + commercialisation Afuah, 1998: 13). Schumpeter (1934) identified capitalism as depending on a continuous stream of innovation. His view was that 'the fundamental impulse that sets and keeps the capitalist engine in motion come from new consumer's goods, the new markets, the new forms of industrial organisation that capitalist enterprise creates.' Hence, new products and methods (processes) were viewed as central to creating competitive advantage. Braun (1998) defines technological innovation in the following way:

'A technological innovation is a new, or substantially improved, technology, or product of technology, that is offered for commercial transactions on the market' (Braun, 1998: 14).

Freeman and Perez (1988) classify innovation into four specific categories: incremental innovations, radical innovations, changes in a technology system and changes in techno-economic paradigm. Incremental innovations do not involve a great leap in technology (Braun, 1998: 14) they include the re-design of existing products that meet a particular product weakness. Incremental change may be stimulated by customer responses to products. It is less likely that an incremental innovation is a result of deliberate R&D than other types of innovation. Radical innovations on the other hand involve the application of new technologies and scientific knowledge through deliberate R&D. It is conceivable that successful radical innovations may create new markets, even industries and increase productivity in relation to production technology (Braun, 1998: 15; Coombs et al. 1987). Changes in technology systems are based on several radical and incremental innovations and can impact on multiple markets and industries. Such innovations can give rise to new sectors and potentially affect managerial and organisational change. Finally, changes in the techno-economic paradigm (e.g. ecommerce) impact on the technological system that may have a major influence on the economy of a country or globally. Such an innovation is likely to lead to the emergence of new products, services, systems and industries in its own right that affect almost every other branch of the economy (Freeman and Perez, 1988: 47).

Many authors make the distinction between product and process innovations (Dussauge et al, 1987; Holt, 1988; Goodman and Lawless, 1994). Innovation is often used as a generic term to describe both these types (Goodman and Lawless, 1994). However, Porter (1985) analyses them in relation to technological change within the generic strategies set out in his work. In general, this strategic emphasis placed upon product or process innovation (Porter, 1985) varies in accordance with the stages of the product lifecycle (Abernathy and Utterback, 1978).

> *'Product Innovation: Differentiation requires the development and enhancement of product quality, features, deliverability, or switching costs. The focus should be on meeting the needs of a particular market segment better than broadly targeted competitors'* (Porter, 1985: 178).

> *'Process Innovation: Differentiation requires support for higher tolerances, greater quality control, more reliable scheduling, faster response times and other means to raise buyer value. The focus is likely to be on developing the value chain to segment needs in order to raise the buyer value'* (Porter, 1985: 178).

Anderson and Tushman (1997) point out the fundamental differences in product and process innovations. Product innovations normally affect more links in the value chain (Porter, 1985) than do process innovations. Customers must be made aware of new products but they are often unaware of process innovations. Process innovations usually make the product better and cheaper without necessarily disrupting upstream (e.g. suppliers) and downstream (e.g. customer) linkages. This supports Porter's (1985) view that *'process innovations are not simply changes in equipment'*. Henderson and Clark (1990) take broad product and process innovation categories and develop specific technological innovation types. Incremental innovations involve improvements and refinements in existing products or processes. Radical innovations are the development of totally new concepts (Ford and Saren, 1996: 84). Modular innovations involve changes in core components without altering a product's overall architecture. Architectural innovations deal with a product's configuration but have little impact on underlying components. Writers such as Goodman and Lawless (1994) and Chesbrough and Teece (1996) have categorised product and process innovations by way of specific characteristics. Goodman and Lawless (1994) identify what they call individual innovations and synergistic innovations. Individual refers to a one-dimensional innovation that does not rely on any significant adjustments in other dimensions of the product or process for its success. Hence, the innovation does not impact on other products and processes. A synergistic innovation requires interactive adjustments between or among several parts of the innovation and its surrounding processes. Chesbrough and Teece (1996) define similar categories as autonomous and systemic. Autonomous innovations are comparable to individual innovations identified by Goodman and Lawless (1994) and are pursued independently of other products and processes. Systemic innovations are realised only in conjunction with related, complementary innovations in much the same way as synergistic innovations. The types of innovation are fundamental to the choice of organisational design according to Chesbrough and Teece (1996).

> *'When innovation is autonomous, the decentralised virtual organisation can manage the development and commercialisation tasks quite well. When innovation is systemic, members of a virtual organisation are dependent on the other members, over whom they have no control. In either case, the wrong organizational choice can be costly'* (Chesbrough and Teece, 1996: 69).

Afuah (1998) identifies further models and frameworks to understand innovation including Abernathy and Clark's (1985) model; Innovation Value-Added Chain (adapted from Porter's value chain identifying suppliers, customers, and complementary innovators who add value to an innovation); and Strategic Choice which deals with innovation strategy options (Freeman, 1991). However, as Afuah (1998) points out these models and frameworks are rather static as only a cross-sectional view of the firm is examined in relation to capabilities and knowledge of the firm.

> *'The models do not look at what happens with the innovation following first adoption. The only dynamism in them is that there is a change from the old to the new'* (Afuah, 1998: 31-32).

Therefore, Afuah (1998: 45-50) examines a number of models he describes as dynamic because they take a longitudinal view of innovation and explore the evolution of the innovation after its introduction. The models he identifies view technology as a key element of the innovation process and evolution and see technology as having a life of its own with radical and incremental phases. The models described are:

- Abernathy and Utterback (1978) (radical product innovation to dominant design to incremental innovation)
- Tushman and Rosenkopf (1992) (similar to the previous model although the process is seen as more complex depending on factors other than those internal to the technology)
- Foster's (1986) S Curve (shows that the returns on the effort put into a technology fall off as the limits to the technology are approached)
- Afuah (1998) Integrative Dynamic Model (the integrative dynamic model is based on the collection of information based on four key questions about the introduction and exploitation of innovation).

The first three models are discussed by Dussauge et al (1987) and are seen as key elements in the strategic management of technology. Whichever model is utilised it is clear that innovation is a 'total process' (Berry and Taggart, 1994: 342) and its outcomes can take many forms. The definitions and discussion highlight these many forms but for the purposes of defining innovation in relation to the research Roberts' (1987) view is applicable as it covers the key aspects of innovation at the organisational level discussed in this section:

- an innovation can be incremental or radical in degree
- innovation is the modification of existing entities or entirely new entities
- innovations are embodied in products, processes or services orientated toward consumer, industrial or governmental use
- innovations are based on single or various multiple technologies

The discussion shows that innovation is a dynamic process starting with an invention (i.e. idea) leading to the manufacture of a product and ultimately its sale. As stated by Berry and Taggart (1994: 342) there are many stages of implementation in the innovation process. The strategic management of technology is concerned with this process and how by strategically managing technology innovation may be achieved.

2.3 THE STRATEGIC MANAGEMENT OF TECHNOLOGY (SMOT)

This literature has developed over the past three decades with the realisation that technology is a strategic resource that must be managed to provide value for an organisation. Drejer (1996) identifies a number of stages in the development of SMOT. During the 1970s, technology was considered peripheral in relation to product, process and system development with businesses and organisations as a whole (Meyer and Roberts, 1988). Technology management was conventionally viewed as a tactical issue rather than one of strategic significance. However, during the 1980s and particularly in the 1990s technological considerations have been recognised as critical strategic factors. The literature now views technology of equal strategic importance to other functions such as marketing, finance, HRM and production (Roberts, 1983; Pavitt, 1986). For strategic decision makers the management of technology must be built around a number of distinct parts each involving varying issues, tools, scope and perception within the business environment. Drejer (1996), discusses the distinct areas or schools of thought underlying the management of technology, which are briefly described below (see Table 2.1 for summary).

	R&D Management	Innovation Management	Technology Planning	SMOT
Perception	Stable, simple and expanding	Changing, but predictable	Changing and discontinuous	Changing discontinuous, unpredictable with new dimensions
Scope	Manage R&D resources	Manage innovation in the entire company	Manage technology across the company	Manage and integrate technology with other aspects
Issues	People, ideas, funds and culture	Conception, invention and exploitation of technology	Analyse and plan the complex process of technological development	Deal with all the dimensions of technological evolution
Tools	Technology forecasting budgeting	Delphi forecasting, technology forecasting, project management of the innovation process	Scenario writing, technology analysis and planning	Strategic MOT, organisation - technology approach to MOT and integrated MOT.
Authors	Porter Jain and Triandis Rubenstein Edosomwan	Roberts, Burgleman and Sayles, Henry and Walker, Loveridge and Pitt	Monger, Roussel et al. , Maack, and Clarke	Dussauge et al., Betz, Bhalla, and Gaynor

Table 2.1. : Development of the Strategic Management of Technology (Drejer, 1996)

R&D Management: Drejer (1996) identifies the starting point for the R&D Management school as the S-curve of technological development. Technology is seen as having a dynamic lifecycle passing through various stages of development. The basic premise is that organisations should invest funds in technological developments so that they may benefit from higher levels of performance. Science and R&D are closely linked in the process of technological innovation. Drejer (1996) points out that R&D is not normally considered a top management responsibility. Rather, R&D is viewed as a black box into which corporate leaders place money and resources to increase technological performance and therefore harvest the benefits.

Innovation Management: Drejer (1996) points to the S-curve as the basis for understanding the nature of technological change that can be incremental or radical. When technological life cycles are short, it is not sufficient to focus on R&D and expect to gain the benefits of all performance improvements. Innovation management distinguishes between invention and innovation. Innovation is broadened out and not only includes technological lifecycles but also in business terms should include elements of every function within the innovating organisation. The innovation management literature views technological change as unpredictable (Drejer, 1996) but has developed a number of techniques and tools to identify technological discontinuities (Delphi method - see Linstone and Turoff, 1975).

Technology Planning: The school is seen as a reaction to a business environment which is no longer perceived as simple or stable (Drejer, 1996). With increasing technological progress and greater competition technology has become increasingly important as a competitive tool of organisations. Hence, with technological change ever harder to predict the technology planning school is based on a set of analytical tools. Such tools include portfolio analysis, inventorying technological assets, mapping technology types (see Dussauge et al, 1987).

SMOT (Strategic Management of Technology): Rothwell & Zegveld (1985) argue that shortening technological life cycles and globalisation changed the dynamics of competition. These changes led to the SMOT literature moving further from the anticipation of technological change towards the way in which technology can be used to create competitive advantage. The move also arose out of dissatisfaction with traditional approaches to the management of technology. Traditional approaches did not improve the rate at which technology could be absorbed, technologies were not strategically considered and often failed to yield significant improvements in performance and the social consequences of technology are not considered (Drejer, 1996). The strategic management of technology school is distinct from R&D management, innovation management and technology planning as it places technology in the strategic arena. However, the three other schools are not ignored within the SMOT school and continue to add value and understanding to the literature. The management of innovation benefits from a strategic approach and therefore the literature has continued to develop corporate, business and R&D strategy to formally include technology. Ultimately the aim of the SMOT literature is to develop distinct technology strategies that provide a competitive advantage and benefit the development of innovations.

2.4 TECHNOLOGY AND STRATEGY

The previous discussion illustrates that assumptions have varied over time and increased in complexity. This has led technology/innovation to be thought of more specifically as a central element in an organisation's competitive strategy:

> *'......to gain comparative competitive advantage by complex, costly and rapidly changing technology, firms need to manage technology strategically'* (Dodgson, 1991: 96).

There has been a rise in the empirical and theoretical research relating to technology and its relationship to strategy development (Freeman, 1991; Coombs et al, 1987 and 1994; Dussauge et al, 1987; Dodgson and Rothwell, 1991). The SMOT literature has placed technology firmly in the strategic management arena including at the level of corporate and business strategy (Porter, 1987; Dussauge et al, 1987).

> *'In order for both corporate and business strategies to be developed in a sensible and balanced manner, the technology of a firm must be well integrated into the strategy-making process'* (Dussauge et al, 1987: vii).

Roberts (1987) argues that the strategic management of technology includes both strategic planning and implementation aspects at two levels within the firm:

- overall at the corporate or business level for the technology intensive or technology dependent firm
- at the functional level within specific departments or areas of activity, e.g. R&D.

Therefore, within the strategy literature (Coombs, 1994; Bowman, 1998; Johnson and Scholes, 1999) there are strong arguments for various levels of strategy to be considered. Johnson and Scholes (1999) identify the levels as corporate strategy, business unit strategy, and operational strategy (concerned with how the component parts of the firm deliver the corporate and business level strategic direction). Similarly Coombs (1994) identifies four strategy levels in relation to the Strategic Management of Technology: Corporate, Business, Innovation and R&D. Corporate and business strategies are recognised as important in developing competitive advantage through strategic planning and practice. At a relatively basic level strategy is defined as:

> *'....the direction and scope of an organisation over the long term: which achieves advantage for the organisation through its configuration of resources within a changing environment, to meet the needs of markets and to fulfil stakeholder expectations'* (Johnson and Scholes, 1999: 10).

Coombs (1994) views corporate strategy as the most important as it can bring business unit control, technology and R&D resources together within the firm. This is only effective if based on business strategy, technology strategy and R&D whether implicitly or explicitly. Technology strategy is much broader than either innovation strategy or R&D strategy and incorporates many of the approaches taken in those strategies. The following sections define the particular strategies identified and highlights the value of technology in strategy considerations.

2.4.1 Corporate Strategy

Corporate strategy is concerned with diversification and competitive advantage for the overall business. It should be noted that a corporate strategy can be developed while supporting and improving the current overall business. Porter (1987) identifies the key concepts of corporate strategy that go on to aid the development of a particular corporate strategy these are: portfolio management; restructuring; transferring skills; and sharing activities. Porter (1987) sees corporate strategy as the means to make the corporate unit greater than the sum of its parts:

> *'Corporate strategy is concerned with the overall purpose and scope of the organisation to meet the expectations of owners or major stakeholders and add value to the different parts'* (Johnson and Scholes, 1999: 11).

Johnson and Scholes (1999) view corporate strategy as very broad asking a number of key strategic questions: what set of businesses should we be in?; how are they to be run in structural and financial terms?; what resources are to be allocated to the different businesses?; how attractive is or are the potential or existing industries?; what is the cost of entry or sustaining?; and will the organisation be better off? It therefore encompasses the totality of the firm and its interaction with the environment (Birley, 1989)

To choose a corporate strategy and create stakeholder value as well as competitive advantages companies must clearly define their role and objectives, have the skills necessary, and be organised. Strategy should not be set in stone but be able to evolve. Porter (1991: 251-253) identifies seven key elements through which a firm may choose its corporate strategy.

- Identify the interrelationships among already existing business units.
- Select the core businesses that will be the foundation of the corporate strategy.
- Create horizontal organisational mechanisms to facilitate interrelationships among the core businesses and lay the groundwork for future related diversification.
- Pursue diversification opportunities that allow shared activities.
- Pursue diversification through the transfer of skills if opportunities for sharing activities are limited or exhausted.
- Pursue a strategy of restructuring if this fits the skills of management or no good opportunities exist for forging corporate interrelationships.
- Pay dividends so that the shareholders can be the portfolio managers.

Technology can play an important role in the development of corporate strategy. Although this may depend on the characteristics of the firm given their business, environment, markets. Goold and Campbell (1987) categorise firms into corporate styles: financial control; strategic planning; and strategic control. The latter two are likely to see firms having some central R&D activity. Therefore firms will utilise the R&D department to acquire and develop technologies for commercial gains such as creating new business opportunities (Coombs, 1994).

2.4.2 Business Strategy

Business strategy is based on decisions about which products and or services should be developed for which markets and the way in which these meet customer/market demands to achieve the objectives of the organisation. Business strategy plans the practices for a firm's activities in individual markets/industries. Bowman (1998: 5) identifies five questions that must be addressed in order to develop a business strategy:

- what markets should we be trying to compete in?
- how should we try to compete in those segments?
- what key competences do we need to build to realise this competitive strategy?
- what do we look like now?
- how can we move forward?

> *'Business strategy or business unit strategy......is about how to compete successfully in a particular market'* (Johnson and Scholes, 1999: 12).

Technology at this level according to Coombs (1994: 386) tends to be dominated by the business strategy with the technology portfolio having to be structured to hit specific business 'targets'. Therefore, product and process innovations will be viewed at degrees of relative importance dependent on the business targets. The two will also differ for a firm which chooses a cost leadership strategy against a product differentiation strategy (Porter, 1987).

2.4.3 Innovation Strategy

A major innovation usually consists of the results of a great many discrete R&D projects which contribute to different parts of the innovation. It is also likely that projects undertaken with a particular innovation in mind may well eventually be used in a completely different context. Freeman (1991) suggests a variety of innovation strategies that are open to firms dealing with technological change (see Table 2.2). However, any classification or taxonomy is arbitrary and should not be regarded as a definitive description of behaviour in the firm. The classifications for innovation strategy are: offensive; defensive; imitative; dependent; traditional; and opportunist. Freeman (1991) clearly states that these typologies are simply heuristics - guides or maps to assist firms and strategic decision-makers in making sense of individual behaviour and of firm behaviour. The two most important environmental influences on the innovating firm are market possibilities and technological or scientific opportunities (although obviously there are others - political, labour market, economic, educational).

Innovation Strategy	Strategy	How
Offensive	The firm aims to establish technical and market leadership by the rapid introduction of new products.	R&D is absolutely crucial - research intensive. Access to basic scientific knowledge. Rapid exploitation of new possibilities. Patents are very important to the firm. Education
Defensive	Main difference lies in the nature and timing of innovations - not first, but not left behind.	Good at production engineering and marketing Patents are also important to a defensive strategy emphasise product differentiation + technical services to attain market share do not produce exact copies of products introduced by OS - they try to improve them
Imitative	The imitative firm is content to follow.	They tend to have very close links between R&D and the manufacturing process. Highly efficient at getting products into the marketplace. Low labour costs or access to cheap resources
Dependent	A subordinate role in relationship to a stronger firm	will rely on customers or the parent firm Unlikely to have any serious R&D capacity usually strong in production engineering
Traditional	Little change in products - conditions may approximate to that of perfect competition	No R&D. The firm may 'import' process innovations. It is likely that the firm will be craft - based
Opportunist	The strategy implies identifying a niche and offering a product or service	Access to expertise Access to knowledge

Table 2.2: Summary of Innovation Strategies (Freeman, 1991)

2.4.4 R&D Strategy

R&D strategy aligns the allocation of R&D resources to projects which help to achieve the stated company's objectives (Twiss, 1995: 41). Such a strategy must make a contribution to the organisation by indicating the value of technology based strategic change. To have value R&D strategy must be aligned to the corporate and business strategies and aid in guiding innovation strategy as well as technology strategy. Strategy formulation is an interactive process based on an examination of possible strategies, forecasts and resources. It should be guided by corporate and business strategy to ensure project selection is right for the company. Ignoring corporate strategy is likely to prove resource costly and at worst fail. As Twiss (1995: 53) puts it '...projects are truly independent only when unlimited resources are available. ......maximising the contribution from the whole R&D portfolio may, therefore, occasionally result in the rejection of a project which might otherwise appear attractive.'

In comparison to corporate strategy, where resource allocation is between functions, R&D strategy is the allocation of resources between projects relating to the corporate environment and involves the balancing of a portfolio of projects where technology is a key business concern. Both projects and business concerns are aiming at strategies for the long to medium term. In developing an R&D strategy such tools as gap analysis, product life cycles, forecasting, risk analysis and capability analysis are crucial. Twiss (1995) identifies several strategies for R&D that strongly relate to innovation strategies: offensive, defensive, interstitial and maverick. The first two are very similar to Freeman's (1991) definition of innovation strategy. Interstitial strategy aims to identify the competitions' weakest point and attack it by exploiting a gap in the market (similar to niche marketing). Maverick strategy aims to apply new technology in which a company has expertise to launch new products in someone else's market. The aim is to reduce the size of the total market via innovation. The initial advantage must be backed by an offensive strategy in order to secure long term success. Such strategies, which will include the examination of licensing and acquiring technologies are valuable in the approach taken to R&D given resources and the environment. As Drejer (1996) has shown R&D management is key to the SMOT process and the development of a technology strategy.

2.4.5 Technology Strategy

It is recognised that decisions about the management of technological innovation must be incorporated into corporate strategy and business strategy if firms are to establish competitive advantage (Dussauge et al, 1987; Coombs, 1994). Berry and Taggart (1994) identify the importance of technology as both a global issue and 'change agent' and support Dussauge et al's (1987) view that technology is one of the principle drivers of competitiveness. The development of a technology strategy will specify, within a given horizon, targets for the development of technological advances as well as the acquisition and exploitation of new technologies. It must be integrated within the overall corporate strategy and support such a strategy (Lowe, 1995). Technology strategy is an essential part of a firm's competitive strategy because innovation is now the principle way to challenge established competitors. Porter (1983: 1) states that *'technology can be at the foundation of creating defensible competitive strategies for firms'*.

Porter (1985) argues that firms respond to five competitive forces and this leads to the development of four generic strategies: cost leadership, differentiation, cost focus and differentiation focus. Each strategy is based on a product or process development strategy. Table 2.3 identifies the strategies and the ways in which they can be met in terms of product and process development.

	Cost Leadership	Differentiation	Cost Focus	Differentiation Focus
Product Development	Lower Material Inputs Ease of Manufacture Improve Logistics	Enhance Quality Enhance Features Deliverability	Minimum Features	Niche Market
Process Development	Learning Curve Economies of Scale	Precision Quality Control Response Time	Minimum Costs	Precision Quality Control Response Time

Table 2.3: Generic Strategies for Product and Process Development (Porter, 1983)

Wilson (1996) proposes that a technology strategy should cover the three interrelated areas of product, process and systems development. Ford (1988) sees technology strategy as centring on the policies, plans and procedures for acquiring knowledge and ability, managing that knowledge and ability and ultimately exploiting them for profit. Dodgson (1991) however argues that there are numerous difficulties in satisfactorily defining technology strategy. His definition envisages technology strategy as involving understanding between senior management that is diffused throughout the organisation. The understanding relates to the importance and potential of technology for the organisation's competitiveness, how this potential is to be realised, and how this complements other aspects of strategy. Porter's (1990) work like much of the mainstream industrial economics (see Tidd et al, 1997: 68) has underestimated the importance of technological trajectories, firm specific technological competencies, and the implementation of technology strategy.

> *'Technology strategy is that aspect of strategy which is concerned with exploiting, developing and maintaining the sum total of the company's knowledge and abilities'* (Ford, 1988: 85).

In developing a technology strategy there are two management processes which need to be considered: strategic planning and strategic thinking (see Drejer, 1996). A planning based process generally assumes that market-power is the source of competitive advantage and is result-focused. As for the strategic thinking process, this acknowledges the economic and non-economic responsibilities (see Porter, 1985; Ansoff, 1965; Leavitt, 1964; Miles and Snow, 1978; and Mintzberg, 1979). Zahra et al (1994) identify six major elements of technology strategy: technological innovation posture; dominant technological thrust and goals; globalisation of technology strategy; technology sourcing; technological investments; and organisational mechanisms. The technological innovation posture is similar to Freeman's (1991) innovation strategy in that firms can be first to market, fast followers, imitators and late entrants. Possibly the most comprehensive discussion on how to develop and formulate a technology strategy is contained in the work of Dussauge et al (1987). The authors cover the elements seen in Zahra et al (1994) and place great emphasis on forecasting and the technological audit as primary 'Analytical Tools'. Strategy formulation is viewed as rational, based on the gathering of information at specific areas and environments in which the organisation operates. Forecasting models are mathematical, econometric, analogy, and expert opinions. The technology audit is concerned with making and inventory of existing technologies and assessing their strengths and weaknesses. Some of these tools will be discussed, examined and utilised in Chapter 4.

Key writers agree that technology has competitive and strategic implications and clarity has developed regarding how technology strategically fits with corporate strategy. Technology strategy does not necessarily have to be developed in its own right, as the key to its potential success in competitive advantage is its integration with corporate strategy (Berry and Taggart, 1998). Chase et al (1998; 121) studied firms that had made technology a competitive weapon by effectively integrating their technology and business strategies. There is a danger in small firms being too technology focused (Berry, 1996). The long-term growth must be guided by the corporate strategy but this strategy must emphasise a match between cross-functional organisational competencies (including technology) and identified commercial market needs (Berry, 1996: 496). Berry and Taggart (1998) extend this relationship between technology and corporate strategy. Utilising work by Itami and Numagami (1992) they link corporate and technology strategy. Itami and Numagami (1992) view the relationships as highly dynamic and extremely interactive in the following three ways:

1. Current strategy capitalises on current technology - this focuses on the matching of a firm's chosen corporate strategy and the current technological competence of the business. Technology in this case can act as a weapon, as a constraint, as a threat to be guarded

against. As a weapon the firm has technology that has some advantage over competition. As a constraint the strategy must find ways to capitalise on the firm's limited technologies. As a threat, technology can force the firm to match competition and industry trends by again making best use of the technology it has. The strategy is implicit and based on the technological limits of the firm.

2. Current strategy cultivates future technology - if the first is achieved then the likely-hood is that technological accumulation will occur providing the firm with the potential for the future over and above current technological developments. This strategy occurs when there is a matching between strategy and technology that is being pursued in earnest whilst the technology being accumulated is greater in its potential than current short-term needs.

3. Current technology drives cognition of future strategy - the writers suggest that a firm's current commitment to technology and technological development will inherently influence management's perception of the firm's future strategy. Technology is seen to drive cognition of a particular strategy because it channels and activates idea generation processes and helps integrate these fragmentary ideas.

The choice of modes and the ability of a firm to undertake one or other of them is dependent upon the stage of technological evolution within the firm. Berry and Taggart (1998) also state that the choice of strategy is dependent on the relationships between those looking at and understanding technology and the corporate strategy formulators. Therefore corporate strategy impacts on the choice of technology strategy. Berry and Taggart (1998: 893) conclude that technology strategy and corporate strategy are intimately linked.

2.5 SMOT IN SUMMARY

Technology is a valuable element in the strategic decision making process. An organisation's innovative capacity and competitive advantage are linked to the value placed on technology at the corporate and board level. The importance of technology has increased over the last 20 years and companies, both hi-tech and traditional, see technology as a means to sustain their position in a particular market or industry and where possible to develop value and competitive advantage. Success is increasingly measured by how firms utilise and balance technology at both the process and product levels in order to meet the market and customer needs and this success and ability must be driven by the corporate strategy (see Berry, 1996). Below, based on the discussion in this chapter, I identify the key areas of the strategic management of technology:

- incorporation of technology at the strategy decision making level (corporate level)
- management of skills and knowledge that can lead to product and process application
- management of technology for competitive advantage
- identification and exploitation of economic, technological and competitive developments through internal interrelationships and also external interrelationships
- integration of technology at all levels of the firm from R&D to Finance.
- technology strategy should include innovation strategy and R&D strategy

Generation	Key Features
First/second	Simple linear models - need pull, technology push
Third	Coupling model, recognising interaction between different elements and feedback loops between them
Fourth	Parallel model, integration within the firm, upstream with key suppliers and downstream with demanding and active customers, emphasis on linkages and alliances
Fifth	Systems integration and extensive networking, flexible and customised response, continuous innovation

Table 2.4: Five Generations of the Innovation Process (Rothwell, 1994)

SMOT provides a theoretical basis for aiding managers in the management of innovation. The innovation process has been modelled over the years and Rothwell (1994) discusses five generations each with varying ways of viewing and managing innovation (see Table 2.4). Rothwell (1994) views innovation as a multi-factor process that is increasingly facilitated by IT-based networking and requiring high levels of integration at both intra- and inter-organisational levels. The key feature that emerges from his work is the identification of networking to aid the management of technological innovation. The literature (Rothwell, 1994 and Tidd et al., 1997) clearly sees innovation as a process and influences on the process can be manipulated to affect the outcome. Networking is one of those influences that can be manipulated or managed to affect the outcome (see Rothwell, 1994; Afuah, 1998).

2.6 SMOT AND NETWORKS

Dodgson and Rothwell (1991) introduced the term 'networking' specifically in their examination of the strategic management of technology. However, they made no attempt to detail how relationships are established and sustained. The term 'networking' is used in its generic sense rather than as a means of identifying key links in the innovation process (Jones and Smith, 1997).

> *'There is considerable evidence to show that innovation today has become significantly more of a networking process'* (Rothwell, 1994: 43).

A number of the factors developed by Dodgson and Rothwell (1991) I believe have both SMOT and network elements. Factors such as external orientation and management skills are defined by Dodgson and Rothwell (1991) and earlier by Dodgson (1989) as requiring close linkages with primary suppliers, accessing external know-how and adopting a horizontal management style with increased communication between functions. These require, at the very least, linkages between key actors to achieve the desired goal. Hence, networking plays an important role in the five factors of the Dodgson and Rothwell (1991) framework (see section 2.8). In his later work Rothwell (1994) fails to develop the original framework's network perspective in terms of links in the innovation process. Jones and Smith (1997) use the Dodgson and Rothwell (1991) framework to examine the strategic technology management in a mid-corporate firm. The network perspective gives added importance to the work by delineating the ways in which external relationships were established and sustained. However, the research lacked real in-depth network analysis and did not follow specific network conventions.

A key element in Dodgson and Rothwell's (1991) framework is how firms access technology and knowledge. R&D, collaborations, licensing, sub-contracting, universities amongst others are documented as means to access technology. The resource-based view of managing innovation suggests that human and technological assets cannot be infinitely manipulated as a means of maximising competitive advantage. Hence, larger firms with greater resources may have an advantage over small firms or firms with fewer resources. Burns and Stalker (1961) showed large firms to have more mechanistic structures and therefore less able to manage innovation whereas more flexible forms of structures, as seen in small - medium firms, can provide a means of better managing innovation. Much of the early research on networks concentrated on the constraints they imposed on members, organisational groups and innovation. For example, networks were seen to prevent the introduction of 'superior' technologies or products by controlling supply and distribution. Recent work suggests that networks may provide opportunities (Galaskiewicz, 1996; Rothwell, 1994) because different activities are systematically related to each other and through repetition combine to form transaction chains. The role of a network can be different for each of its members and therefore there is always the possibility of change: *'This inherent instability and imperfection means that networks develop over time'* (Tidd, et al, 1997: 211).

The limited network element in the SMOT literature has tended to concentrate on the means of acquiring technology which are well documented (see Dussauge et al, 1987; Freeman, 1991). Dussauge et al (1987) discusses the main types of structures and networks that may be used to acquire technology. Freeman (1991) also identifies a number of network types including: joint ventures - R&D corporations and joint R&D agreements; licensing; associations; and investment/acquisitions. Collaboration and strategic alliances are also seen as a major networking phenomenon in the SMOT literature and have been viewed in the last decade or so as one of the most striking developments in industrial organisation (Dussauge et al, 1987). It is these collaborative agreements that have the main focus in the SMOT literature.

2.6.1 Acquisitions

Porter (1987) suggests the importance of acquisitions as a way of meeting business objectives. Unlike internal R&D, acquisitions can provide a faster means of obtaining new technology. Acquiring a firm with technologies, skills, competencies and possibly innovations may be attractive as it offers much lower initial costs of entry into a new business/market or industry. The major downside is the possibility of the unfamiliarity of that acquired business which is likely to mean management may find it difficult to manage a business they do not understand.

2.6.2 Strategic Alliances

Firm heterogeneity is reduced when a firm is able to overcome barriers to resource mobility and gain access to specialised, tacit capabilities (Teece, 1987). Strategic alliances allow firms to procure assets, competencies (or capabilities) that are not readily available in competitive factor markets, particularly specialised expertise. The literature defines strategic alliances as any voluntarily initiated co-operative agreement between firms that involves exchange, sharing, or co-development and it can include contributions by partners of capital, technology, or firm-specific assets (Harrigan, 1985; Gulati, 1995). The primary focus of strategic alliances has been on understanding the resource based considerations that promote the formation of alliances (Hagedoorn, 1993). Technological alliances can be defined as relationships where firms co-operate, on the basis of their technological capabilities, with their current or potential competitors. Alliances generally only cover part of the activities of the firms (see Gulati, 1995). Hence, two partners may be developing a technology jointly (sharing technology) but yet may still be competing within other markets through their existing technologies. The reasons why a firm might wish to enter into an alliance with another firm can be viewed in two ways. The first is for economic reasons and the other is for technological reasons. These two are however not mutually exclusive as technology has an economic role to play. According to the transaction cost model,

> *'there is no reason for entering into an alliance or transaction which is free of risk and does not require specific skills or equipment'* (Williamson, 1985: 157).

Originally, Williamson (1975) argued that vertical integration would be a solution to the problem of suppliers being uncertain, suspicious, opportunistic and therefore possibly discouraged from entering into joint transactions. However, Williamson (1985) softened the approach with quasi-vertical integration and relational contracting. Removing the possibility of bureaucratic rigidity and providing benefits that are seen in smaller flexible firms. A strategic alliance is a relational contract based on some strategic imperative. Such alliances are characterised by frequent transactions, reduced costs, reduced risk and better long term investment. These characteristics are categorised as frequency, uncertainty and specificity. In terms of technology, the role of the alliance and the conditions for considering and undertaking the use of networks is to access technology. Alliances are common where internal costs and risk is high due to the lack of resources and the strength of the competition. A firms overall capabilities may be lacking in a particular area or skill.

2.6.3 Licenses

These provide a way for firms to access technologies developed in other industries or by competitors in the same business but operating in other geographic areas (e.g. Pilkington

Glass licenses its glass-making process to competitors - Dussauge et al, 1987: 46). Licenses can reduce the freedom of firms since they normally entail strict limitations concerning the use of the technology and still require the internal competencies to utilise the technologies for competitive advantage. Licensing does however provide rapid access to proven technologies and can reduce the financial exposure of the firm (Roberts and Berry, 1985).

2.6.4 Joint Ventures

Joint venturing based on technology is a phenomenon that became widespread in the 1980s (Dussauge et al, 1987). This continued during the 1990s with projects getting larger, technology more expensive and the cost of failure too large to be risked alone. Joint venturing becomes an option to overcome these increasing difficulties and disadvantages to acquiring technology. Like strategic alliances it allows two firms to share costs, risks and resources to develop technologies, possibly for the same but sometimes different purposes. Increasingly common are links between firms and higher education institutions particularly in the bioscience industry.

2.6.5 Human Capital Transfers

Sometimes the reputation of a firm or the tacit nature of one of the firm's key competencies resides with particular individuals within the firm rather than with the firm as a whole. When this is the case, tacit or intangible assets become tradable through human capital transfers between firms. Top management succession arid the recruitment from competing firms of key personnel with specialised knowledge or technical expertise are two examples of this.

2.6.6 Social and Professional Relations

Like strategic alliances and human capital transfers, social and professional relations among firms exemplify the porous nature of firms' boundaries and the interpenetration of firms within and across industries. Social and professional relations refer to friendship ties, business clubs, industry trade associations, and professional and occupational associations.

2.6.7 Educational Acquisitions (Roberts and Berry, 1985)

Through links with university research centres, and hiring university graduates with particular technological skills a firm can gain a 'window' on technology. They can stay familiar with new technology, without necessarily intending to use them thus reducing costs and risks from internal development. There is also the increasing use of the teaching company scheme that places a student with a firm. This can be used by a firm to access particular students who are researching in particular fields and hence may offer an insight in new technologies not previously known to the organisation.

The possibilities for accessing technologies can lead to companies developing innovative forms of decentralised networking by which knowledge and technology may be produced jointly and shared (Humbert, 1993). Networks play an important role in bringing clients, suppliers and companies with complementary technological assets together (DeBresson and Amesse, 1991). In gaining such advantages, one must still anticipate the disadvantages. Companies will have to share control of part of their business for some time and this means careful consideration of which areas of knowledge, skills and technology are worth sharing. Assets may be both strategically and critically important and sensitive to a company and thus, sharing such areas may reduce the edge a firm has over its competitors. Potential solutions are identified for such problems and although not detailed here are a key part of the SMOT process described by Jones and Beckinsale (1994).

Papers by writers such as Ford and Thomas (1997), Doz and Hamel (1997) and Gulati (1998; 1999) show that there is value in providing a network perspective to the SMOT literature. Ford and Thomas (1997) show that a firm is categorised not only by the configuration of its technology (see Porter, 1987), but by its relationships with and linkages to the systems, or discrete technologies, of others. The point being that a technology strategy is inevitably a network strategy. This is not a surprising statement given the need for innovative firms to acquire and exploit technologies that can be risky and very costly. Ford and Thomas (1997) view external networking as important to gathering knowledge, skills and resources for the purposes of technological development. The writers develop a company technology system similar to Porter's Value Chain (1987) in which each of the key actors in the network relate to a technology or technologies. The paper still deals with systems at the organisation level with firms or departments as the focus rather than at the level of individual actors. Three cases are examined in terms of how they perceive their position in a technology network, the process of acquisition, resources used and required and the management and exploitation used by the firm. Finally, the authors claim that the SMOT approach is limited with regards to its network dynamics especially in the development of networks over time (Ford and Thomas, 1997).

In Doz and Hamel's (1997) paper actors are viewed as organisations rather than particular individuals with the authors looking at the transfer and management of capabilities and competencies through networking. The weakness is the lack of individual network actor analysis and therefore an answer to how competencies and capabilities are shared is quite general. However, the paper clearly shows the role alliances, and therefore networks can play in the implementation of technology strategies.

> *'...alliances have a key role to play in the implementation of technology strategies, and more generally of corporate strategies'* (Doz and Hamel, 1997: 578).

The question that arises is whether strategy has a role to play in the creation of a network? Gulati (1998) goes a stage further than Ford and Thomas (1997) by considering alliances not simply as dyadic exchanges but more in relation to how the alliance is shaped and defined including the precursors, processes and outcomes associated with alliances. Gulati (1998) introduces social network theory to the study of strategic alliances although the focus remains on the firm rather than individuals.

> *'........the primary focus of research on alliances has been to ask the 'why' question, which focuses on understanding some of the reasons firms enter alliances, structure in certain ways, manage and change them, and performance benefits sought..... this leads to an avoidance of the 'how' question, which focuses on some of the conditions under which certain behaviour and performance outcomes are likely'* (Gulati, 1998: 295).

Gulati (1998) sees social networks as important and influential in the creation and success of alliances. He examines how a firm is embedded in its environment through social networks and it is these social networks that are valuable conduits of information, rather than technology, in order to provide opportunities and constraints for firms and can have important behavioural and performance implications for their alliances. The paper is a literature review and helps understand where the social network perspective can be of value in understanding alliance processes. In a later paper Gulati (1999) examines the influence of network resources on alliance formation and argues that networks are a key element in accessing resources, providing opportunities and an advantage in forming alliances.

2.7 THEORETICAL AND PRACTICAL LIMITATIONS OF LITERATURE

The previous section highlighted the developing literature that integrates SMOT and networking. However, this work has the same empirical and theoretical limitations of the earlier SMOT literature: concentration on large firms, strategic management viewed in relation to organisation or department, generic view of networking and limited examination of relationships and studies generally based on successful technological development.

The SMOT literature tends to concentrate on large organisations that have substantial commitments to R&D (Dodgson and Rothwell, 1991). Technology scanning for example demands considerable in-house skills to identify important new technologies and assess their likely impact on the business. With the difficulties of managing technology in smaller firms the literature has tended to ignore the importance of links to corporate strategy although there is growing recognition of the benefits of alliances for SMEs (CEST, 1990: Contractor and Lorange, 1988; Forrest and Martin, 1992). A small firm's limited staff and financial resources can govern the development of technology management and strategy. Managers are less likely to have undergone formal training and therefore may be unaware of basic analytical techniques associated with technology management and strategic decision making. It seems that gaining competitive advantage through innovation/technology strategies in small firms will be an emergent rather than deliberate process (Whittington 1990; Jones and Tang, 1996a). Competitive advantage is often based on: concentrating on part of a product or system; focusing on a niche market; and/or forming a partnership with a similar size company. Rothwell (1989) believes that the innovative advantages of small firms are derived from their flexible managerial structures that are more responsive to changes in the marketplace. However, SMEs generally have inadequate R&D resources and are 'information constrained' which makes them highly dependent on external sources of technology. The literature often neglects the context within which technology strategies are generated, chosen and implemented (Berry and Taggart, 1998: 887). Berry and Taggart (1998) also identify a number of writers who argue forcefully that formal strategic management procedures are inappropriate for small firms due to the limited management and financial resources. In order to overcome some of these deficiencies the use of new organisational structures can aid the high-tech SMEs in orientating themselves to access technology and in order to understand the market (see Bahrami and Evans, 1987).

The descriptions of strategic alliances, joint ventures and collaborations are useful in defining types of agreements and inter-firm relationships that access technology and knowledge when internal resources are limited. However, they are limited in their understanding of the details of the relationship and how it impacts on the strategic management of technology. There is without question a networking process being put in place when a technological alliance is entered into however the network understanding is limited. The theoretical analysis has tended to concentrate on the transaction cost approach (Williamson 1975, 1985). Pisano (1989, 1990) utilised the approach in terms of in-house R&D versus collaboration. Hagedoorn and Schakemraad's (1990 & 1992) evolutionary framework researched and examined inter-firm collaborative agreements as well as strategic behaviour in relation to what leads firms to try to enhance their competitive position and as a way of accessing knowledge or learning when partners want to acquire some critical knowledge (Gulati, 1998). Therefore, the SMOT literature is limited in its understanding of networks and generalises the concept under the heading of acquiring technology and views the network as a strategic management process. Coombs et al (1996: 35) state that *'work in this area has been carried out from a number of disciplinary perspectives...... and .....the object of investigation has also varied between studies'.*

As mentioned in relation to Ford and Thomas's (1998) paper the organisational level tends to be the focus of networks in the SMOT literature. Little, if any consideration is given to the inclusion and analysis of other departments or individuals. Networks such as strategic alliances can be categorised into what Conway (1997) calls a 'relational' approach: focusing on relationships and structure between organisations. This macro view limits the dynamic understanding of networking and its relationship to technology strategy. The studies of strategic alliances and joint ventures also tend to see the links as a 'total' network and not as a 'partial' network underlying the alliances (see Conway, 1997). Hence ignoring the internal and external links among individuals as well as departments/functions. Research into SMOT generally is characterised by studying networks that have produced successful innovations. Studies tend to start from the point when the network has already dissolved and generally moved on and only informal ties still exist (Freeman, 1991). As stated by DeBreeson and Amesse (1991: 369) 'research on networks has tended to ignore the study of why such networks dissolve or fail'.

It is therefore the objective of this thesis to utilise the SMOT framework outlined in the following section to meet these deficiencies. A new framework should provide strategic decision-makers in traditional mid-corporate firms with a way of modelling their proposed network for the purposes of acquiring technology and knowledge. For researchers it should provide a means of examining innovation networks and aid the understanding of the processes that are affecting the network over time. The framework should be able to develop with changes in the network under analysis examining both SMEs as well as large organisations and map the strategic processes in conjunction with innovation processes.

2.8 SMOT FRAMEWORK

These limitations of the SMOT literature have begun to be addressed especially with the development of the social network perspective in alliances (Gulati, 1998). Dodgson and Rothwell (1991) set out the major features of corporate technology strategy in SMEs by examining data from three studies: The Industrial Research and Development Advisory Committee Study on R&D; The Small Firms Linkages Study; and The Celltech Study (see Dodgson and Rothwell, 1991: 46). Drawing on these studies the authors identify five factors which influence corporate and technology strategy in SMEs and mid-corporate firms which also have strong links with the tools required in the strategic management of technology:

1. Accumulated Technological Competencies: Firms with wider ranging R&D expertise, and greater R&D resources - financial, managerial and personnel - are better placed to deal with the threats and opportunities emerging from rapidly changing technology. It is clear that a broad base of competencies and skills offer greater potential and methods for dealing with change, offering options and technology scanning. Competencies can be gained more often through externally acquired knowledge via joint ventures, licensing and academia.
2. Internal Strategic Cohesion: Successful technology strategies are always integrated with other key areas of corporate decision-making including finance, investment and marketing. SMEs possess considerable potential advantages over large firms in their ability to develop and communicate cohesive and cogent strategies. Their size ensures more effective flows of information and communication within the organisation, both horizontally and vertically. There is a stronger tendency for more knowledgeable strategy formulation.
3. Organisational Specialisms: It is widely acknowledged that smaller firms have more organic structures than larger firms do (Ackroyd, 1995). One of the major issues in SMOT

and technology strategy is how best to achieve conditions of organisational flexibility. Three aspects are identified by Dodgson and Rothwell which give SMEs an advantage: architecture, the physical environment and the way it is designed to encourage communication; climate, the openness and support for innovation; and systems, methods for consultation and direction of effort i.e. less isolation of R&D employees.

4. External Orientation: It is very important for firms and especially SMEs to increase their external orientation by examining technologies in a wider context. External bodies can play a key role in the development of organisations' strategic management. Such external bodies may include government schemes, public sector inputs, public R&D, collaborative R&D, and contract R&D. There is a strong element of this in the acquisition of technology as well as being aware of you environment and markets.

5. Management Skills: In viewing technology strategically managers have a major role to play through technological assessment, forecasting, building and obtaining benefits from collaborative links, communicating strategic objectives between and within functions, and integrating technology strategy with corporate decision making.

These factors broadly cover the elements required to understand the strategic management of technology in smaller firms but also link closely to SMOT and innovation theories that have been recently developed. This is supported by the fact that technology affects most aspects of the firm's strategy and its impact must therefore be taken into account at all stages of the strategy-making process. Technology is indeed essential in the first of these stages, strategic segmentation, which aims at identifying the relevant business units on which strategy will be based. Moreover, technology directly affects the value of businesses as well as the forces that structure competition and technology is one of the main sources of competitive advantage. Technology can be an appropriate lever for diversification where a firm enters a new business because it has the technological skills required. In Table 2.5 I identify tools and principles which may be used to link the selection of technologies with the formulation of strategy linking closely to the five factors outlined. It is these tools and theoretical underpinnings that I shall examine in Chapter 4 in the context of the five factors and the variables that relate to them. The five factors have particular theoretical standpoints that assist in their understanding, value and analysis. This is important because the theory will aid in developing the networking aspect of the framework (see Chapter 4) to support and strengthen the discussion later in the thesis.

Factors	Related Concept	Key Writers
Accumulated Technological Competencies	Competencies; Complementary Assets	Prahalad and Hamel; (1990); Teece, (1997)
Internal Strategic Cohesion	Communication; Committees; Rules and Procedures	Coombs et al (1987); De Meyer (1991); Humbert (1993); Jain and Triandis (1997)
Organisational Specialism	Organisational Structures; Structure in relation to environment; embeddedness of businesses in environment.	Burns and Stalker (1961); Lawrence and Lorsch (1967); Dodgson and Rothwell (1991)
External Orientation	Licensing agreements; joint ventures; accessing conferences, information from regulatory bodies and government. Marketing, Customers, Suppliers.	Dodgson (1989); Tidd et al. (1997)
Management Skills	Forecasting; Procedures, Project Management; Audits, Technology Types; Life Cycle Models.	Dussauge et al (1987); Dodgson and Rothwell, (1991); Pearson (1992); Twiss (1995); Tidd et al (1997)

Table 2.5: The Five Factors and the SMOT Tools and Related Concept

2.9 CONCLUSION

In this chapter I have discussed the development of literature related to technology management. Drejer (1996) argues that SMOT began with R&D management, developing into innovation management and then technology planning. The development of the SMOT literature has placed technology in the strategy arena. The SMOT literature provides rational frameworks for strategic managers to consider explicitly technology in their decision-making processes. Technology is now seen as a key element of their corporate strategy. I have identified from the literature three levels of technology strategy within corporate strategy (Berry and Taggart, 1998). This identification may provide a basis to examine technology strategy in relation to the innovation and network process. The SMOT literature (Rothwell, 1994) identifies networking as a key element in the innovation process. The literature treats networking in terms of inter and intra organisational linkages at the firm or department level rather than at the individual actor level (dyadic links). This is without doubt the case in terms of strategic alliances and joint ventures. The research focus is on the technology and why it is being developed or acquired rather than the importance of the actors involved in the innovation process surrounding that technology. Therefore this has tended to leave gaps in the examination of alliances as well as the general innovation process. Having examined the literature a number of questions raise themselves:

- what can traditional firms do to make themselves more strategically aware and access new technology?
- what are differences and similarities between independent and non-independent mature small firms?
- does corporate/technology strategy impact on the types of internal and external networks? - what is the relationship between strategy and networks in the firms?
- how does technology strategy/SMOT impact on the network during the networking process whether it be licensing, collaborations, general contacts in the industry?
- what role do the actors play and are there varying processes of network development?
- can technology impact on network choices, actor choices and development?
- how and in what way do networks change over time?

It is also clear that another key element of SMOT is internal organisation and internal networking. Success of networking in SMOT is about bringing together elements (internal) such as marketing, production, engineering and finance. Coombs et al (1987) and Porter (1987) show clearly how important the synergy of all the companies resources and elements are key to innovation and technological development. Like any strong strategic decision making at any level all strategies drawn up should be flexible and open to critical review given continually changing circumstances. Increasingly, the technological market place is becoming more global and fluid. This requires greater flexibility from the firm and this is where SMEs are seen to have some advantage over large multinationals albeit that their complementary assets tend to limit their competitive market.

Finally, I discussed a SMOT framework that can be utilised in the understanding of networks and networking within the innovation process. Dodgson and Rothwell (1991) identify five key factors in the SMOT process each requiring the use of networks to be successful. This network perspective is underdeveloped by the authors although I believe it can be modified to provide a stronger analytical framework. The purpose being to examine technology and the innovation processes in order to understand the dynamic network processes underpinning an innovation as well as the impact strategy and structure may have on the network process or vice-versa.

Chapter 3: NETWORKS

CHAPTER 3

NETWORKS

3.0 INTRODUCTION

In Chapter 2 I discussed the strategic management of technology (SMOT) literature. In doing so I identified the network limitations of the literature and where the literature may be improved. In an attempt to achieve this, the thesis must examine the network literature. Within the SMOT literature the limited network perspective relates to inter-organisational relations rather than intra-organisational relations or a combination of the two. However, within the network literature the interest in actor networking has produced a large body of research that is highly diverse. The concept of networks has developed over a number of decades and in the last ten years has increased in terms of organisational relations (Olivers and Ebers, 1998: 549). Olivers and Ebers (1998) suggest that this work has not resulted in an all-encompassing conceptual theory of networking. There is little agreement on what constitutes a network and often the term has been criticised for being vague and all-inclusive (Tidd, et al, 1998; DeBresson and Amesse, 1991). The development of network theory and research began with many inter-related disciplines and perspectives such as anthropological/sociological science (Barnes, 1954); organisational theory (Lawrence and Lorsch, 1969; Allen, 1971); information systems (Ciborra 1990; Ebers 1993). Mitchell (1969) identifies Barnes' (1954) study of a Norwegian town parish as one of the first social network studies. Merton (1957: 369) introduced the idea of ego-centred networks or personal networks later developed by Rogers and Kincaid (1981). Mitchell (1969: 12) later conceptualised what he termed the total and partial network of a society based on social network theory. Since the 1960s the network literature has slowly begun to develop specific network types with an increasing set of literature in the 1980s and 1990s. Network types include regional networks (Cooke, 1996), learning networks (Pinch, 1998), dynamic networks (Miles and Snow, 1987 and Hobday, 1994), strategic networks (Jarillo, 1993), R&D Networks (Allen, 1971) information networks and knowledge networks (DeBresson and Amesse, 1991). More recently the term innovation network has developed (Freeman, 1990; Hagedoorn and Schakenraad, 1992; Autio, 1997; Conway and Steward, 1998; Conway, 1997; Jarillo, 1993). Actor network theory (Callon, 1986; Latour, 1999), regional networks, policy networks and supply chain networks have enriched the understanding of innovation networks (Jones et al, 1999). Such literature has aided the view that networks are more than an aggregation of bilateral relationships between firms and therefore the configuration, nature and content of the network can add value to the organisation. Interest in networks has crossed the boundary into the strategic management of technology literature with work on inter-firm alliances (Gulati, 1998; Oliver and Ebers, 1998; Grandori and Soda, 1995) and technology strategy (Ford and Thomas, 1997).

I will now examine the network literature distinguishing between various ways in which networks are studied and described. I then examine network definitions and identify work relating to the categorisation of networks as well as network types. The objective is to understand the general network literature as well as that pertaining specifically to innovation. I will identify limitations of the network literature and consider whether these correspond to those of the SMOT literature. Finally, I discuss the way in which networks can be studied and analysed. The quotation below is indicative of literature that assumes networks have value in various disciplines. However, the ways in which the network approach has been used varies dramatically and often is limited as seen in Chapter 2. My ultimate aim is to combine the networking and SMOT approaches into a unified conceptual framework because as stated by DeBresson and Amesse, 1991:

> *'the network approach has something original, useful, and durable to bring to innovation studies...........the concept of network may provide a bridge between disciplines.'* (DeBresson and Amesse, 1991: 363)

3.1 NETWORKS

According to Fombrun (1982), the term 'network' is an abstract notion referring to a set of nodes and relationships that connect them. The term has been used in a variety of social sciences including organisation theory, neuro-sciences, operational research, communication theory and small group theory. Mitchell (1969: 1-2) saw the term 'network' as purely metaphorical and far different from early social networks identified by Barnes (1954).

> *'The social network is a specific set of linkages among a defined set of persons, with the additional property that the characteristics of those linkages as a whole may be used to interpret the social behaviour of the persons involved.'* (Mitchell, 1969: 1-2)

The literature contains a number of approaches to understanding networks (Katz, 1966; Mitchell, 1969; Hagedoorn and Schakenraad, 1992; Grandori and Soda, 1995; Conway and Steward, 1998). Already mentioned is the metaphorical approach where the network may be studied in terms of a 'web' of relationships (Mitchell, 1969). However, both graphical and mathematical approaches also exist with the later utilising quantitative statistics (Conway, 1997; Conway and Steward, 1998). Since the early metaphorical network literature based on societal interactions the examination has developed into an institutional issue consisting of organisations, governments, business units, universities, customers acting as nodes with links and interactions. Social network theory's importance stems from the fact that networks have several links between actors and these links may be accorded different values or qualities (Katz, 1966: 203). More recently, networks have been claimed as a hybrid form of organisation which potentially could replace both firms (hierarchies) and markets whereas others believe them to be simply a transitionary form or organisation, positioned between internal hierarchies and external market mechanisms. Curran and Blackburn (1994) take this latter view making a distinction between organisational links and external links made by senior organisational figures. The authors' definition based on the business owner or entrepreneur is clearly important to the innovation and SMOT process but does not account in detail for internal links or type of interaction.

> *'Networks' and 'Networking' have become common notions in discussing how businesses connect with their environments. Networks can take the form of contacts that business owners have with other actors ranging from accountants, solicitors ect. They therefore might be conceptualised as theorised constructs abstracting particular types of interaction which may occur between the owner-managers or other organisational representatives and the external environment of the enterprise'* (Curran and Blackburn, 1994: 30).

This thesis is specifically looking at the role of networks in the strategic management of technology to improve innovation and competitive advantage. In this sense, networks lie at the very core of organisation theory and management theory.

> *'......networks are modes of co-ordination among specialised organisational units; and striking the right balance between differentiation and integration is usually considered a central problem in the structuring of organisation'* (Grandori and Soda, 1995: 183).

The two quotations above are relatively broad in that they identify linkages in terms of 'co-ordination' and 'contacts'. In the case of the Grandori and Soda (1995) the definition is quite simplified in relation to network characteristics and views networks at the level of 'organisation units' and not individual actors. The network literature identifies different network characteristics such as tight or loose (Frakenberg, 1966 and Mayer, 1961), partial or total (Mitchell, 1969), depending on the quantity, quality (intensity) and type of interactions or links (Oliver and Ebers, 1998). Tight or loose knit networks are defined in relation to social redundancy and density of networks. With social redundancy being limited within the context of a tight knit society and therefore the density of such a network being high. The reverse is true of a loose knit network where the density is less and certain individuals and groups are more likely to be ignored. The tight and loose definition is a useful starting point for understanding the characteristics of social networks. Mitchell's (1969) partial and total network definitions are based on social network theory, which at its extreme sees the whole of society as a total network. His work focuses on the process of abstracting particular networks from the total network. Mitchell (1969: 56-57) defines a total network as a first order abstraction from reality and it contains information about the whole of the social life of the community to which it corresponds. The partial network is therefore an extract of the total network based on some criterion applicable throughout the whole network.

The work by Oliver and Ebers (1998) shows that network approaches although diverse are related to four specific areas (social, institutional, economic and strategic). It is these four areas that I believe are key to the definition of a network. In this way, networks are seen to involve different channels of communication and degrees of formalisation including relationships between firms and suppliers. The aim is to share knowledge but such relationships involve strong personal relationships between key individuals. The role of the gatekeeper is often seen as key in general network literature providing the link between organisations. The following quote provides a more generic definition:

> *'A network may be visualised as consisting of a set of actors connected by links, which represent the relationships between the various actors'* (Conway, 1997: 2).

Each person is seen to "act as a node" in a network of equals (i.e. R&D directors) relaying messages between the different areas at all levels. When messages are sent there is unlikely to be any preferred route. The relationship is therefore, both social and an interactive one between groups and individuals.

> *'....the network is both a sphere of relations, a sphere of innovation and a sphere of strategies'* (Fourcade, 1993: 212).

These definitions show the terminology used to describe networks varies enormously. Models have tended to follow the traditional linear view of innovation seeing networks as operational constructs. As Conway (1997) states the new interactive or dynamic model has developed from the literature (see Hagedoorn & Schakenraad, 1992; Hakansson, 1989; 1995). There are many definitions of networks which deal with inter or intra organisational characteristics of networking or view networks as groups or individuals. The understanding of networking in the SMOT literature also undergoes many definitions especially in relation to inter-organisational relationships as identified in Chapter 2 (including strategic alliances, joint ventures) and specific network theory.

There is no single definition that can encompass all the possible ways in which networks can be perceived. Any definition should include the ideas of interactions and relationships between individuals and groups. I believe networks can be defined at varying levels between two individuals, between groups within organisations and between organisations. However, it is still individual actors that ultimately interact. Informal links suggest that the interaction can potentially involve all individuals within different groups. Whilst formal links are most likely to be between specific individuals from those groups. The same may be said for organisations, although the potential for informal links between all actors is far less likely. Conway's (1997) definition fits this view of networks and allows for the differences between networks of individuals, groups or organisations. It is concise and avoids the difficulties of defining different networks. Researching a network and defining it too specifically may constrain the analysis especially as over time networks are likely to change, develop or dissolve and as I discuss later have differing functions and provide differing objectives.

The Oliver and Ebers (1998) view (Section 3.2) will play a key role in identifying, examining and analysing networks through the thesis. The reason being that examining SMOT from a network perspective suggests economic and strategic factors of networking play a key role. For the purposes of the thesis I will characterise networks as follows:

- the whole of society will be viewed as a total network (Mitchell, 1969). That is, any organisation will be an abstraction of the total network.
- the partial network will be a set of actors connected by relationships to achieve a specific goal for the total network - 'focal action-set' (Conway, 1997)
- transactions may be bi-directional and differ between actors within the network
- actors are defined as those who perform activities and/or control resources (Hakansson and Johanson, 1990; 129-130)
- links may be internal or external to the organisation
- links may be contractual (formal) or non-contractual (informal)

In defining what I mean by a network in the context of the thesis I need to take a broader view of the network literature. The aim being to develop the understanding of networks in terms of functions, in terms of types and in terms of limitations.

3.2 INTER-ORGANISATIONAL RELATIONSHIPS AND NETWORKS

Oliver and Ebers (1998) in their examination of the literature distinguish between two clear strands of the literature namely inter-organisational relationships and networks. The first strand tends to explain the type of networking approach taken in the SMOT and innovation literatures with the emphasis on joint ventures and alliances.

> *'Accordingly, the population of our study is defined as `all studies dealing with any type of inter-organisational relations', which thus excludes intra-organisational studies. Only for ease of parlance, shall we refer in the following to this body of research as `interorganizational network research', and subsume under this label both studies of bilateral inter-organisational relationships (for example joint ventures between two parties) and of networks among multiple actors'* (Oliver and Ebers, 1998: 4).

Both strands of the research are viewed to 'have taken distinct developments' and they also share important research interests (Oliver and Ebers, 1998). In general both focus on sets of recurring ties (resource, friendship, informational ties) among a set of actors (individuals, groups, and organisations). Both aim to identify why actors forge specific linkages under different circumstances, and the consequences from the inter-organisational links and the positions of actors within their relationships (Fombrun, 1982; Mizruchi, 1994; Powell and Smith-Doerr, 1994; Stinchcombe, 1990). In their examination of the two strands, Oliver and Ebers' (1998) conclusions support those found in my examination of the SMOT literature with regards networking in that field. They view inter-organisational networking as an intentional response to dependencies among organisations in order to enhance the power and control of the networking organisations in order to foster their success. The methodology also supports some of my own criticisms made in Chapter 2 in that the dominant approach has been to study at the organisational level, with the focus on multiple ties (i.e. department/function or group - rather than dyadic links).

Oliver and Ebers (1998) demonstrate, the network perspective has developed into four particular approaches: the social network; power and control; institutional theory; institutional economics and strategy perspectives (discussed below).

> *'Our analyses demonstrates empirically that these four paradigms (and not three or five others) are the ones that differentiate and unite (!) this seemingly heterogeneous field'* (Oliver and Ebers, 1998: 19).

3.2.1 Social Network Approach

Research utilising this approach has tended to employ the formal apparatus of social network analysis (SNA) in order to examine how organisations and their members are influenced by the structural properties of their internal and external networks, as well as their positions within these networks. (see Burt, 1992; Krackhardt, 1990; Mizruchi, 1994). Burt (1992), in particular, has developed an approach that specifies how different positions within a web of relationships affect the opportunities of the incumbents. With regard to structural network features, studies have focused, for example, on the impact of pair-wise interactions (Shrum, 1990), balkanized or distinct sets of relations (Roy and Bonacich, 1988), or have compared structural equivalence and cohesion as explanations of interpersonal contagion (Galaskiewicz and Burt, 1991). In other pertinent research, the reconstitution of inter-locking ties was traced to specific structural features of the organisations involved (Brewster-Stearns and Mizruchi, 1986; Palmer, 1983), and to the exercise of inter-organisational control (Boje and Whetten, 1981; Davis, 1991). Olivers and Ebers (1998) in their examination of more recent literature see this strand of network theory as having developed in a unique, inductive pattern which has moved research away from formal structural studies. However, some commentators argue that this kind of social network analysis has still some way to go before it constitutes a full and comprehensive testable theory (Salancik, 1995; Stinchcombe, 1990; see Mizruchi, 1994 for a response to selected criticisms).

3.2.2 Institutional Theory Approach

Institutional theory traces the creation of inter-organisational networks and their forms to particularities of the institutional environment, its dominant social institutions and characteristic of the setting in which a network operates. Research (Ebers and Jarillo, 1998; Herrigel, 1995; Lane and Bachmann, 1996; Sabel, 1989; Saxenian, 1994; Scott, 1987; Whitley, 1993a; Whitley, 1993b) has shown how certain political, legal, cultural, industry and/or regional conditions impact the likelihood of inter-organisational network formation. Attributes of the institutional system are therefore viewed as playing a prominent role in explanations of the formation and forms of inter-organisational networks.

3.2.3 Institutional Economics and Strategy Approach

This approach focuses on how actors gain access to, and utilise, resources which will reduce their dependence or otherwise improve their competitive position (Oliver and Ebers, 1998). Such research is concerned with resources and their characteristics and it often conceptualises network ties in organisational, contractual or ownership terms. Scholars have studied, for example, how pre-existing social relations among individuals foster and support the development of more formal business networking relationships among their organisations (e.g. Casson and Cox, 1997; Galaskiewicz and Wasserman, 1989; Granovetter, 1994; Haunschild, 1993; Herrigel, 1995; Larson, 1992). Furthermore, other research has explored how the interdependencies among organisations influence the formation and forms of inter-organisational networks (e.g. Alter and Hage, 1993; Dyer, 1996; Easton and Araujo, 1997; Oliver, 1990; Pisano 1989; Porter and Fuller, 1986; Teece, 1992).

3.2.4 The Governance Approach

This approach studies the institutional mechanisms by which inter-organisational relationships are initiated, negotiated, designed, co-ordinated, monitored, adapted, and terminated (Heide 1994), and combines institutional theory and institutional economics. In contrast to the network perspective, it focuses less on the structural properties of inter-organisational relationships and actor positions. The governance perspective concentrates on attributes of both the networked actors and the form and content of their relationships within a particular institutional context (Ebers, 1997; Gerlach, 1992a; Grabher, 1993; Grandori and Soda, 1995; Hakansson and Snehota, 1995; Jarillo, 1993; Powell, 1990; Ring and Van de Ven, 1992; Whitley and Kristensen, 1995). Potentially, the governance approach may be key to examining the idea of SMOT and technology strategy in relation to networking whether inter or intra organisational. This is because it deals with institutional mechanisms that strongly relate to the networked actors and the content of relationships which is valuable to the SMOT framework factors identified at the end of Chapter 2. In understanding networks and the dynamic and interactive view they may provide innovation theory we must understand their function.

3.2.5 Summary

These approaches highlight the fact that networks occur for particular reasons and may also ensure particular outcomes or at the very least assist in the development of particular outcomes. They suggest that networks can and do function at different levels within and around organisations, groups and actors. The following section identifies why networks exist, the reasons for networks and ultimately what function on a generic level they serve. Adding a number of functions to the work of DeBresson and Amesse (1991).

3.3 NETWORKS AND THEIR FUNCTIONS

In the earlier sections a number of broad functions have been identified including social, economic and strategic. Such networks exist for 'hard' and 'soft' reasons. 'Hard' reasons being formal and explicit contractual relationships and 'soft' reasons being those informal bonds that are forged such as friendship, trust and respect. It is these 'softer' forms that DeBresson and Amesse (1991) argue enable networks to last beyond the formal reasons and possibly make the network successful.

It is common in the literature for networks to be attributed to external reasons or conditions. This is not surprising given that businesses/organisations operate under external pressures, external regulations, competitors and customers/markets. External conditions contribute to organisational uncertainty including technological uncertainty. New technologies require resources and multiple complementary assets that even the largest organisations do not have.

DeBresson and Amesse (1991: 368) provide a detailed examination of the function of networks:

1. Networks can serve as a search and evaluation procedure for the different possible combinations. This is both important internally and externally. That is that strong internal networks can ensure that different possible combinations are examined. Externally, such networks might also include taking part in industry conferences which can lead to somewhat informal networks being developed a provide a potential way to obtain general information on the industry which may provide an indication of what the future may hold. Information must be carefully examined.
2. Inter-organisational form of exchange. The type of exchange may be determined by the embeddedness of technological know how and the possibility that the exchange may be non-exclusive (DeBresson and Amesse, 1991). The value of this form will depend on the type of technology - Enabling, Key, Pacing which relates to the SMOT theory (see Chpt 4).
3. To reduce and eliminate uncertainties and risks. Not all can be eliminated but reductions can be made in risks such as market uncertainties, behavioural uncertainties. Risks such as cost of research and development can be shared thus aiding in the reduction of risk of investment.
4. Networks can be used to set standards, norms, rules, and systems and interface specifications. Example: the computer industry saw the bringing together of competitors to set standards for new technologies as in the case of DVD (Digital Versatile Disc) to store enough data to hold a full 2hr movie unlike current CD which can store 1hr of movie data.
5. A network may also aid entry into markets and industry by reducing costs and providing a door into the market. Obviously the choice of network partner is crucial here. Access may also be obtained by initially being a supplier to a larger firm within a market and over time developing the firm innovative capacity through learning from the customer. There is a risk of being tied to the customer and becoming reliant on a customer but as this thesis will show this can be reduced and ultimately avoided.
6. Also what must be added to this is the importance not just of network partners but also the choice of intra-organisational network actors and the type and content of the relationship. A network approach aids in accessing skills and knowledge not just from external actors but also internal actors. This may allow the sharing of knowledge, skills and information

to aid learning and the development of strategic thinking and decision-making within the organisation when added to external network orientation.

7. Finally, many organisational studies have indicated flexibility as a major property of networks (Grandori and Soda, 1995). Flexibility in the literature relates to the capacity to change a firms' output according to contingencies and also the capacity to change the organisational arrangement itself. The benefits of such flexibility are to lower transition costs with respect to internal organisation -- and some forms of network of being more conducive to self-change than others (Pfeffer and Salancik 1978; Gadde and Mattsson 1987).

Reasons for entering into or being part of a network are the strategic value to actors involved (Jarillo, 1993). The network literature shows that a firm's position in a network is a matter of great strategic importance. This is highlighted in the literature by the categorisation of network types (e.g. strategic networks - Jarillo (1993); knowledge networks - Swan (1996)) along with more generic network types as identified by Grandori and Soda (1995).

3.4 NETWORK TYPES

As discussed in Chapter 2 the SMOT literature identifies a number of inter and intra firm linkages such as joint ventures; licensing; sub-contracting and strategic alliances. However, the examination of these types is removed from the specific study of networks. As the network literature has developed so has the number of types identified to aid function. Initially networks were seen to constrain and prevent the introduction of 'superior' technologies or products by controlling supply and distribution networks. This thinking is highlighted in the work of Granovetter (1985) where strong network ties are viewed to constrain access to innovatory knowledge and information. Increasingly however, networks are seen to provide strategic/competitive advantages by accessing resources through weaker direct and indirect relationships to provide opportunities for innovation (Freeman, 1991; Dodgson and Rothwell, 1991; Grandori and Soda, 1995). So typologies have developed from general formal and informal networks to specific types. Network typologies are shown in Table 3.1. The list is not exhaustive although they are seen as key to the innovation process. These are alternative 'takes' on the more traditional definition of networks. A number of them focus on the nature of the network e.g. formality whilst others on role e.g. learning or innovation. As will be discussed an innovation network is likely to be formed by a regional network, have strategic network traits as well as use learning, knowledge and information networks to inform and benefit the innovation system.

Network Type	Reference
Formal and Informal Networks	DeBresson and Amesse (1991); Kamann and Strijker (1991); Freeman (1991); Steward and Conway (1993)
Regional networks	Cooke (1996); Charles and Howells (1992)
Dynamic networks	Miles and Snow (1986); Hobday (1994)
Supplier/Supply-Chain networks	Sako (1994) and Shaw (1994)
Strategic networks	Jarillo (1993)
Information, Learning and Knowledge networks	Pinch (1998); DeBresson and Amesse (1991) & Swan (1996)
R&D Networks	Price (1963); Marquis and Allen, 1966; Allen (1971); Pearce and Papanastassiou, (1996)
Innovation networks	Freeman (1991); Autio (1997)

Table 3.1: Network Types and Literature Reference

3.4.1 Formal and Informal Networks

As discussed in Section 3.3, networks can be viewed as hard or soft providing two ways of understanding networks as either formal or informal. The formal structure of a network is defensive, instrumental and exists as part of the normal streams of activities. It will likely consist of regulations, contracts and rules. The informal structure is much harder to identify and thus define. It will normally exist to fulfil some social need and is far more dynamic than formal structures. Informal networks are extremely important but very hard to classify and measure. Even so they should not be ignored and any examination of networks must at least acknowledge the role of informal networks in innovation success as well as failure. Examples of informal networks in innovation include Allen (1977); Conway (1994/95) and Steward and Conway (1993). Informal networks may be seen as analogous to 'tacit knowledge' (Freeman, 1991).

> '*although networks can and do involve formal contractual relationships, they cannot be reduced to contingent clause contracts because contingencies are unpredictable*' (DeBresson and Amesse, 1991: 368).

Kamann and Strijker (1991) point out that for networks to last they almost certainly will involve a bundle of multilateral, 'soft' forms of governance, evolving informal reciprocity and the development of trust. They also state that some relations are based on opportunism, some trust and partnerships. This means that there is a normative element involved which may not be recognised as a network or part of the network under study. This hampers visualisation of the network (Kamann and Strijker, 1991). Personal relationships of trust and confidence are very important at both the formal and more so at the informal level. Hence, factors such as language, background, shared ideologies and experiences, among others, play an important role in networking.

3.4.2 Regional Networks

This network type has developed out of research from such regions as Baden-Wurttemberg in Germany (Dussauge et al, 1987; Charles and Howells, 1992). The region has been a top economic performer for well over two decades. Its strength has come in the fact that many different institutions support the region. Both large and small firms operate around institutionally embedded innovation and all firms in the region can access innovation services locally. The regional system is developed in such a way that if one or two firms are lost the whole system will not suffer unduly. Such a regional network requires complementaries between institutions as well as between competition. This type of network has tended to relate to the more stable forms of networking (DeBresson and Amesse, 1991).

Regional networks are economic structures that exist within a nation. Such regional networks offer a locus for technological and economic externalities that benefit the nation as well as firms and individuals based there. Localised or regional networks appear to be more durable than international strategic alliances (see Chapter 2: 47). Studies of incubator firms, spin-offs and start-ups invariably show that locational proximity is crucial to nurturing the early stage of a new innovative venture (Scott, 1991; Saxenian, 1991). Social solidarity, shared education and professional experience it is argued by Bianchi and Bellini (1991) are best sustained through constant interaction and geographic proximity. Hence networks can benefit from interaction and especially proximity and support stronger communication although technology is becoming an important part in this (see Chapter 2).

Key to regional innovation systems and regional networks is the availability of a skilled workforce with the necessary skills and quality. The technological infrastructure has to provide geographical proximity, good communication networks, proximity to key transport links, common cultural background and a well developed infrastructure that provides the ability to utilise innovation potential of the region. Other related factors which potentially are more important to utilising the potential of the region is the proximity of educational establishments, research institutions and universities. Charles and Howells (1992) state that such proximity is beneficial to innovation activity. Public and government support for innovation can play an important role in regional innovation development, as seen in Germany as well as in Scottish regions of the UK. This is especially the case where public decisions affect the retention of skilled labour and education and training.

3.4.3 Dynamic Networks

A network model developed by Hobday (1994) from earlier work by Miles and Snow (1986). The dynamic network is viewed as a specialised system of innovation. It is useful for generating new product innovations and carrying out technical tasks. However, Hobday (1994) argues that it is unable to capture the rewards from its innovations. The network form lacks what Teece (1986) calls 'complementary assets' (see Chapter 4). This is based on the examination of the Silicon Valley model that Hobday (1994) identifies as having limited large-scale production, marketing and distribution resources for exploiting mass market innovations. Hobday (1994: 165) makes it clear that the model functions extremely well as an innovation network suited to the early product life-cycle stage. It is useful for carrying out specialist technical activities and for supplying high technology niche markets. A network model which is similar to that utilised and developed by Japanese *Keiretsus*. Within the dynamic network both large and small firms work in collaboration, responding rapidly to fast-changing market needs, pooling resources, and coping with uncertainty and risk. The networks are such that they are vertically desegregated industrial structures which means that key business functions are performed by independent firms that are co-operating together. Miles and Snow's (1986) version highlights the use of brokers to link partners, providing information to network members and co-ordinating overall operations. The network allows firms to exploit their individual competencies. The aim of the network is to take on board positive elements of structures to benefit the firms such as technological specialisation of functional structures, the market responsiveness of divisional structures and the balanced organisational characteristics of the matrix. As Hobday (1994) points out the success of this network type is far from clear. It is true to say that during the period of Miles and Snow's original work Silicon Valley underwent a boom however, Japan overtook the United States in traded semiconductors around 1986. In Dynamic Random Access Memories (DRAMs) four of the five market-leaders were Japanese or Korean. The United States did regain the advantage in the early 1990s but according to Hobday (1994) the gains were not due to networks but new strategies.

3.4.4 Supplier Networks

An area of networking which has grown into the literature from the very well documented perspective of business relationships/networks (Hakansson and Johanson, 1990; Hakansson and Snehota, 1995) and supply chain management (Walker, 1988; Kaufman et al, 2000). Concepts such as actors, resources and activities have been utilised by the 'Stockholm School' (Clark and Staunton, 1993) to revise neo-classical economic theory. Hakansson's (1987: 493) work in this area has concentrated on product development and his view that the outcome is dependent on many small and independent events. Concentrating on industrial markets, Hakansson (1987) views supply chain relationships as important but the organisation's ability to network is defined by a combination of resources and activities. Writers such as Von Hippel (1988) have encouraged firms to enter into relationships with 'lead' users or first tier suppliers, taken partly from research into Japanese manufacturing practices. Japanese supplier relations research (Nishiguchi, 1994) has confirmed that closer links between firms, their suppliers and customers may help to reduce the cost of components, through specialisation and sharing information. Relationships are seen to vary from very short-term, arm's-length contractual agreements focusing purely on costs to a long-term relationship where suppliers make a significant contribution to the development of new products. Supplier networks in this way can provide benefits such as a reduction in the time to market and improve the integration of component technologies (Tidd, et al. 1997). They also according to Tidd, et al (1997) can restrict the access to technologies and materials through the control of supply chains or supply networks. The types of networks in such relationships can lead firms or even an industry (Swiss Watch Making) into a situation were responding to a change in technology can be constrained by the current network relationships and transaction relationships adopted.

3.4.5 Strategic Networks

As Jarillo (1993: 12-13) points out there have been two basic ways to organise economic activity: vertical integration and subcontracting. Vertical integration has been the dominant form of organisation. This means that one company integrates within its boundaries many or even most of the activities needed to deliver the final product or service. In the last 75 years such organisations have become the standard. A prime example of such integration was the

Ford motor company. Henry Ford set up in-house operations and divisions, from steel making to the assembly operations, as he could not find suppliers who would deliver the usual high standards required to deliver his strategy. If the suppliers had been available Ford may have bought steel from a steel-maker or have had parts made by a third party, theoretically he could have decided not to assemble a car and simply market the cars and subcontract the rest just as Nike does today (Jarillo, 1993). These two forms are not 'pure' in the sense that in nearly every vertically integrated organisation some inputs will be bought-in. Both forms have cost/disadvantages associated with them: vertical integration of a large number of very different activities can lead to a firm loosing focus and giving rise to costs which are out of line with their real competitive position. In the case of subcontracting inputs, technological knowledge is feared to be at risk in terms of passing on key information that if shared can remove any competitive advantage. Companies that adopt a market-based organisation will tend to look for multiple suppliers and customers, to avoid becoming hostage to any one of them. This also has its downside, forcing the company into significant purchasing and marketing expenses.

The advantages and disadvantages can be increased and reduced respectively by providing the long-term planning security of an integrated form, where investment can be made in relationships because they are intrinsically stable. The advantages inherent in being in direct contact with the customer and the technology, being able to innovate faster then de-integrated companies and the entrepreneurial drive of independent firms whilst doing away with the co-ordinating bureaucracy are key characteristics of a strategic network. Strategic Networks are long-term, purposeful arrangements among distinct but related for profit organisations that allow them to gain or sustain competitive advantage over their competitors outside the network, by optimising activity costs and minimising co-ordination costs. Trust is at the very core of what a strategic network is, for it is the mechanism that lowers transactions costs, thus making the network viable economically. Williamson (1981) who first dealt with transaction costs pointed out that they arise through the inability to analyse everything in advance. The fact that in business the future is always uncertain, players are often opportunistic and attempt to take advantage of others. The number of players can affect the suppliers and buyers of the product or service which also gives rise to transaction costs. In the strategic network when one player invests in a specialisation with another it is important that it is only useful to do so when working for the other player. Figure 3.1 shows the interaction between ownership mode and approach to the relationship developed by Jarillo (1993). The top left category describes a company with a strong sense of shared goals, a clear understanding that 'we are all in this together'. It is a co-operative approach and all players belong to the same owner. A company in the top right category has no such goal sharing. Each unit plays by its own rules and often tends to an adversarial relationship with the others. The bottom row shows a typical arms-length market relationship, where independent units compete with each other. Finally the independent units co-operate because there is a belief in a benefit of sharing. The belief is that working with others will be more productive and that productivity will be passed down to the independent unit.

Aston University

Illustration removed for copyright restrictions

Figure 3.1: Interaction between ownership mode and approach to the relationship (Jarillo, 1998)

3.4.6 Information, Knowledge and Learning Networks

The network literature identifies information, knowledge and learning networks as possibly the most simplistic to understand unlike the innovation network type discussed which is the most interactive and difficult to implement (Simmie, 1997). I deal with these three networks under the same heading as they exist to transfer either information or knowledge and to achieve learning through the organisation and there is a strong similarity between the three. Information transfer including data, documentation, software and standards; knowledge transfer includes skills know-how, policy issues, ability to adapt and diffuse innovation as well as impact of technology and processes; and learning involves communication, sharing and inter- and intra- organisational interactions. It must be said that knowledge consists of information and know-how regarding co-operation. Know-how may operate at several levels including individuals, group/team or the organisation and ultimately the network itself. So knowledge is the exchange of qualified information and presupposes communication or direct contacts between individuals (Karlsson, 1994; Kogut et al, 1993)

Information: The literature on information networks aims to address the problems found in bilateral exchange. A network permits multilateral exchange, which should provide access to information that might not be available from a single source. An individual may have many information sources, each independent of each other. The basis for the information network is that any individual within the network can draw information from any other member. It should be remembered that information on its own has no intrinsic value, its value comes in the way it is put to use by the individuals accessing it. Gatekeepers or information gatekeepers have been documented heavily in the literature (Allen, 1971; Tidd et al 1997; Scarbrough, 1999). These are individuals who pass on information from the outside world (external orientation) to others in the organisation for them to use. These people however, tend to rely on contacts for their information rather than on multilateral networks. It must also be stated that information in isolation can be rarely used but often must be mixed and supplemented by other information. An individual is obviously aware of what information he/she has but is less likely to be aware of what others have and what will mix. There is no way that an organisation can handle all the information needed to conduct business purely through employees talking. Procedures and mechanisms are needed. Reports and committees are such mechanisms.

Learning: As pointed out by Tidd *et al.* (1997) different network types present different opportunities for learning. They also make it clear that networking and collaboration can be used as an opportunity to learn new market and technological competencies. The basic idea being to internalise a partner's, a competitor's, or possibly a customer's know-how. This does make the measure of this network type difficult if not impossible. Learning is therefore most likely through networks that involve external linkages and means that a firm/organisation must select a external body, organisation customer that can contribute what needs to be learnt. The same it can be said for information and knowledge possibly equally as much in the case of knowledge. Mutual trust is again a key element and one of the main risks of working in, or forging a network or alliance with another external factor. Interpersonal trust is necessary in any network to facilitate communication and therefore learning. Organisational trust is a little different as it is defined in terms of routines, norms and values that can survive changes in individual personnel.

Knowledge: Knowledge tends to be assembled from information and plays a key role in organisational learning (see Nonaka et al, 1996; Quinn et al., 1997; Scarbrough, 1999). Meaningful information can add to individual or organisational knowledge bases. In contrast to information, knowledge is structured in a complex web of associations. The basis for a knowledge network is to access certain key or strategic knowledge types. One key element in this process is the 'boundary spanner' (Tushman and Scanlan, 1981) who uses networking activities outside their organisational boundaries to acquire and shape knowledge and expertise in their particular field. Boundary spanners can then act as technological gatekeepers by acquiring new forms of knowledge and expertise and then translating this into firm specific technological solutions (Swan, 1996). The knowledge network is the means of collecting knowledge that can be applied to improving the organisation's performance or competitiveness. Knowledge management is a relatively new branch of this theory. Knowledge management and knowledge networks aim to access potentially valuable tacit knowledge or explicit knowledge from individual employees. Ways of creating knowledge come in four modes, which it can be argued, are key elements of the network literature and network variable. The four are (Nonaka et al, 1996): Socialisation (shared mental models and technical skills); Internalisation (learning by doing); Externalisation (a process of articulating tacit knowledge into explicit knowledge); and Combination (combining different bodies for explicit knowledge). There are also ways to safeguard the knowledge including intellectual property laws and patents which provide barriers and prevent the value of the knowledge depleting.

Accessing information, knowledge and learning from these is viewed in the literature by way of networks. The network structure will depend on the nature of the knowledge to be acquired (Tidd et al. 1997). Types of networks might include tactical networks to obtain explicit knowledge (technologies; designs or products) or strategic networks to acquire embedded or tacit knowledge (skills and capabilities). The conversion of tacit to explicit knowledge is a critical mechanism underlying the link between individual and organisational learning. Individual knowledge is amplified within an organisation through the processes of dialogue, discussion, experience sharing and observation. The knowledge network is therefore an expanding community of interaction which can and does cross intra- and inter- organisational levels and boundaries (Tidd et al. 1997). Potentially such networks may give rise to reinforcing internal divisions by importing inter-professional conflict into organisations. Work in this area is just developing with research by Swan (1996) and Scarbrough (1999) beginning to address the question of conflict in the management of both inter and intra organisational knowledge networks.

3.4.7 R&D Networks

As Conway (1997: 10) points out individuals in this type of network are organised around scientific or technological specialities and have a distinctive set of technical and cognitive norms. R&D networks have developed from the early work on the social organisation of science which as pointed out by Jones et al (1999) focused on defining the principal norms governing scientific activity (see Barber, 1952). The network has tended to be classed as informal. Price (1963) categorised the scientific network as the 'invisible college' representing elites of highly productive scientists engaged in the informal transmission of information. But as Conway (1997) points out it is broader in its scope as it includes both scientists and engineers in either a public or private organisational setting. The research into R&D networks has distinguished scientists from engineers with the social organisation of the two being viewed as different. The differences are explained in part by varying sets of norms (Marquis and Allen, 1966; Allen 1977). Engineers 'are limited in forming 'invisible colleges' by the imposition of organisational barriers' (Allen, 1977:40). Hence engineers only work on problems that are of interest to the employer.

Communication has tended to be a key focus of the network literature relating to engineering-based R&D (Allen, 1971, De Meyer, 1985/91). The communication networks internal and external to the R&D process clearly equate to links and relationships between R&D actors and external actors for the purposes of successful R&D. Suggesting quite strongly that R&D networks may be put in place. 'Architectural design thus becomes an important determinant of the structure that an organisation's communication network will assume.' Allen (1971: 21). Allen (1971: 21) continues by suggesting that such factors must be taken into account and properly arranged in order to effectively couple the R&D project to its supporting information systems. The literature suggests that R&D networks may exist within an individual organisation's R&D department or between organisational R&D departments. R&D laboratories may be centralised or decentralised (Goodman and Lawless, 1994). This is likely to influence various R&D network types and provide differing opportunities for each (Pearce and Papanastassiou, 1996). In many ways the R&D network can remove some of the potential limitations inherent to engineers as identified by Allen (1977).

Within a single organisation there may be extensive mutually supportive knowledge networking between the decentralised labs (Pearce and Papanastassiou, 1996). However, strategic alliances may be achieved between R&D laboratories that are functions of different organisations. Internal and external linkages between R&D network actors can be of value to support the organisation's interests as well as to develop weak ties (Granovetter's, 1973), which are an important potential source of knowledge and information to stimulate opportunities for R&D and innovation such as to:

- maximise the commercial effectiveness of a major new product concept
- minimise costs
- minimise risk
- access resources not available elsewhere
- generate ideas and then products for commercial advantage
- make best use of available technology in-house and externally

3.4.8 Innovation Networks

As shown in Chapter 2 the innovation literature (Dodgson and Rothwell, 1991; Conway, 1997; Jones et al., 2000) acknowledges that networks are central to the effective management of new technologies. All activity is embedded in complex networks of social relations including: family, state, educational and professional background, religion, gender and ethnicity (Granovetter, 1985). The actor-network approach (Callon, 1986; Latour, 1999; Law and Hassard, 1999) sees technical creation (innovation) as stemming from numerous interactions. These interactions between particular researchers, scientists, technologists, engineers, managers, customers and users are actors within an innovation network. The relationships may take place at the personal and organisational level. Also such relationships are sometimes analysed in terms of the 'transaction costs' (Williamson, 1975; 1985) which are incurred in the purchase of materials, components or technologies. While others argue that trust (Sako, 1992) between individual employees and a firm's customers and suppliers is an essential feature of business relationships.

Conway (1997) summaries innovation networks: 'The network approach focuses on the diversity of actors and the plurality of formal and informal relationships that must be mobilised for innovation to occur. During the 1970s and 1980s there was a marked dichotomy between those studies of inventive and innovative activity that adopted a socio-centred 'relational' approach (focusing on relationships, structure and exchange) and those employing an ego-centred 'entitative' approach (focusing on individual actors and inputs and the innovation process). The relational approach was essentially located within the sociology of science literature, while the 'entitative' approach was more typical of the studies concentrating on the management of innovation. Until recently, research based on the relational approach has examined general inventive activity rather than investigating specific innovations. For example, Crane (1972) and Allen (1977) examined the social organisation of scientists and engineers at the micro level. In contrast, studies investigating specific inventive activity leading to a particular discrete innovation have largely ignored the relational aspects. Studies have focused on the sources of inputs (customers or suppliers) and their role in stimulating innovation or problem solving (Myers and Marquis, 1969; Achilladis et al, 1971; Langrish et al, 1972; Gibbon and Johnston, 1974).'

With the increasing interest in networks and networking, the two streams have converged and the relational approach has emerged into the mainstream innovation literature and slowly into the SMOT literature (see Chpt. 2). Researchers are increasingly studying both discrete as well as general innovative activity. Innovation networks offer many benefits of internal development (research and development) with few of the drawbacks of collaboration as discussed in the SMOT literature. The network literature specifies the context in which firms conduct innovation. Unlike in the SMOT literature the modelling of innovation analyses the interrelationships between social, economic and technological systems. The components and linkages within such systems are also identified and form the basis for analysis. Components and linkages include:

- other firms, customers and suppliers; educational institutions
- research laboratories as sources of skilled labour and knowledge
- government agencies as sources of finance, regulatory constraints and support for innovation
- banks and venture capitalists

- actors within the organisation that provide access to such components and linkages as well as bringing their own skills and abilities to the innovation process.

3.4.9 Summary of Network Types

The network types identified can be solutions for organisations to achieve particular goals and objectives. A networking solution is not for all organisations but there are characteristics that a business system has to have to make it beneficial. The networks described have varying natures and roles providing advantages and disadvantages in alternative situations and for differing objectives. If managers are to decide on entering a network in the formal sense then the advantages and disadvantages must be considered. They must be gained in its critical activities when carried out in a de-integrated way. To give more detail advantages are gained when:

- there are widely differing optimal scales. This means that there are both optimal ways to perform some activities through very large companies whilst some are best carried out by small ones.
- some activities may require a very specific 'culture' or mentality within the company. Therefore if the relevant mentalities vary widely across the different activities in the business system, a de-integrated relationship will probably be more efficient than trying to keep them in-house and then creating more or less artificial barriers between them.
- the business is such that innovation comes mostly through the entrepreneurial motivation of relatively small units. Gains in efficiency are best made through small improvements or incremental improvements.
- when the different activities that make up the business can expect to make widely different rates of profitability. This is most likely where the barriers to entry and competitive advantages apply to them in widely different degrees.
- when there is a need for co-ordination exceeding that which is available through simple subcontracting.
- regional advantages are available. Regional location can effect and impact on the efficiency and ability of undertaking a networking solution.

The network types show different advantages and disadvantages exist and can provide benefits as well as difficulties depending on a number of factors. However, like collaboration and alliances in Chapter 2 there is little difference between networking and alliances in terms of key factors that must be addressed or in place to make the structures efficient and potentially successful. Therefore network types at the very least are likely to vary in terms of:

- the degree of impact on the network given the resources and knowledge that the firm may already have
- the type of invention and potential innovation i.e. incremental or radical
- the corporate and technology strategy employed by the firm and possible external firms involved in the network
- the availability of information and knowledge external to the firm
- the risks identified by strategic decision-makers as well as management
- the technological protection and dependent on whether firm is innovating to be offensive, opportunistic or defensive (Freeman, 1991) in terms of innovation strategy.

3.5 NETWORKING LIMITATIONS, ISSUES AND PROBLEMS

On examining the network literature as with the SMOT literature there are similarities in the way in which innovation networks are researched and examined. These relate to the level at which the networks are examined and the access to information. DeBresson and Amesse (1991) point out that the literature lacks clarity on the limitations and problems of networking. It must be said that many of the limitations and areas that might lack clarity are evident in the SMOT literature also. Problems and limitations with the literature are related to specific issues of firm size, network costs, why networks dissolve or fail, retrospective view taken when researching networks, how they develop over time (time serics); embeddedness and systematic uncertainties for firms.

3.5.1 Firm Size: The literature makes clear distinctions between large and small firms. However, the importance of firm size in the literature and how the value of networking may vary depending on size is rarely discussed. The assumptions are that small firms have limited resources where-as large firms have increasing resources. However, the literature fails to discuss the impact of this on ability and power within the network.

Entrepreneurs: Frequently, entrepreneurs pursuing niche strategies find further growth by diversification and this diversification is particularly effective if it pursues further niche opportunities. Both formal and informal ties will exist for the entrepreneur who will, if growth and success is the goal, have to strengthen the weaker ties to prevent some of the stronger ties dominating and solely benefiting from information and technology. Opportunities and alternatives are key to the success of the entrepreneur within a network.

Small Firms: Burns and Dewhurst (1989) argue that generally small businesses will not be able to survive, in the long run, in industries where economies of scale exist and are important to competitive advantage. In this case the small firm must grow and aim to become a larger firm to ensure survival. The other area in which such firms tend to exist is where economies of scale exist but where the product is limited. This can occur in the highly specialised industries. This is called following a 'niche strategy'. This is important for a small firm since it offers a better chance of selective, sustainable growth (Burns and Dewhurst, 1989). As stated by Jones et al. (1997) until an SME is established and its structure is relatively sophisticated and organised the entrepreneur will dominate the network organisation. For the entrepreneur the network offers social support, extends the strategic competencies; identifies threats and opportunities; and supplements internal resources.

The literature on networks and small firms concentrates heavily on the area of regional networks. The examination of such networks relates to economic growth in post war Britain and more recently to the growth of the SME sector and rationalisation and employment reduction. SME literature increasingly emphasises the growing importance of networks especially in accessing technology. Without innovation, existing product portfolios will slowly die, processes will be outmoded, advertising lose credibility and the source of sustained profitability dry up (Baden-Fuller and Pitt 1996). Economically, given the above statement and the fact that an SME has limited resources relative to a large firm/multinational, SMEs are reliant on networks to develop product and process innovations and to access potential technologies. The major problem for SMEs is accessing the right network and developing the strategy that does not lead to involvement in technologies that could ultimately prove economically disastrous or at best fail to produce. The lack of specialist capacities (lack of awareness of innovation possibilities due to low resources and knowledge bases and limited expertise) can affect a small firm's approach to innovation and external sources of support. Firms are likely to be constrained in their use of external sources of support due to the lack of awareness about innovations developed in other firms, inventions, industries and public institutions. Certainly this is supported in a great deal of the literature (Simmie, 1997) with many statements beginning with 'the majority of SMEs remain small and have a lower level of impact on employment and output'. However, there is a minority of small firms taking the risk of trying to innovate and grow through different types of networks.

Large Firms: As in the SMOT literature, the network literature is strongly biased towards the analysis of large firms certainly over the 250 employees size and geared towards high-tech firms and the actor nodes are also analysed at the level of the organisation rather than individual actors. However, Hobday's (1994) examination of Silicon Valley highlighted that the size of firms within the network can affect the outcomes. Hobday suggests in his work on dynamic networks that small firms are unable to develop beyond their niche marketing abilities unlike larger firms with their greater resources and influence. Even when the dynamic network is there to benefit the mass market. This is probably because within the dynamic network the large firm becomes king or the technological leader. The larger firm in the network is likely to benefit over a small firm when the network benefits the mass market.

3.5.2 Retrospective View: From the literature reviewed on networks and specific innovations there is a tendency to take a retrospective view of networking or to utilise existing case studies to develop the analysis. This, in my opinion has lead to the lack of interactive understanding in network theory and fails to offer a dynamic view of networks in the Strategic Management of Technology. The problem with the network literature relating to technology management and innovation are the analytical approaches used. Often, the research results are descriptive or presented in some table form based either on qualitative aspects or quantitative statistics. Both are useful in forming a basis for the understanding of networks in innovation but the view is simply a list of linkages. Qualitative data is based on prior knowledge and not current information, decisions, management. Which means information may be missed, forgotten, ignored when interviews and questionnaires are answered (Auster, 1990; Conway, 1997). I believe that this retrospective view taken in the research also impacts on the fact that networks have been rarely examined in terms of why they dissolve or fail.

3.5.3 Dissolve or Fail: The literature argues that small firms are more likely to suffer innovation failure than large firms (DeBresson and Amesse, 1991). Resources are seen to be a key element in such failure. Also, where small firms are jointly working with larger organisations as part of an innovation network, small firms can suffer from a lack of power over external network actors (Hobday, 1994). This is because small firms often lack the resources and ability to take an innovation to market especially where markets are removed or differ from the firms market base. Hobday's (1994) work although not specifically examining network failure does give a general insight into why networks may fail which is quite rare in the network literature. Researchers concentrate on successful and stable network forms (DeBresson and Ammese, 1991) often supported by a common regional identity, possibly due to the fact that managers are prepared to talk about success rather than failure. It must be stated that in terms of networks identified in the SMOT literature (Chapter 2) the reasons for failure of strategic alliances is somewhat better documented. However, such alliances (networks) are often researched on a global basis and are therefore seen as much more volatile due to distance, costs, skills, time, travel, trust, communication and risk. Failure as a result of involvement in a network can come from differing or diverging strategies and power (see Hobday, 1994), incompatibility of assets, and co-ordination costs. As Hobday (1994) and DeBresson and Ammese (1991) pointed out the most obvious reason for a firms failure in a network is due to its exclusion by other partners/actors in the network

3.5.4 Embeddedness: The trend towards a more collaborative mode in industrial systems has important implications for firms. Most firms operate within an interlinked industrial system (Autio, 1997). What this means is that firms are suppliers or customers of firms within an industry or providers of value to another firm. Collaborations are usually undertaken vertically but there is reason to believe that this vertical collaboration has begun to shift into a more horizontal form with SMEs undertaking some form of agreement in order to share tasks, undertake R&D jointly; share information; even share employees. This leads to the potential for increased flexible specialisation among SMEs. As stated in the section on innovation networks (3.4.7) all activity is embedded in complex networks of social relations (Granovetter, 1985). The same can be true of individuals as well as groups or organisations although relations may vary. This is an important concept in the sense that it has several implications for barriers to growth and strategies applied by firms. It is also an important concept because the more embedded a firm the greater the adjustments to its competence pool.

Autio (1997) defines embeddedness as the strength, intensity, and permanence of links between the firms and their operating environment. Another important element is that as a firm becomes more embedded in its environment then this can often mean that many of the firms assets and even competencies may have little value outside the situation. Autio's (1997) study takes an overall look at the concept of embeddedness of SMEs in terms of technology, manufacturing, customer interface, barriers to growth, and strategies applied by the firm and breaks these down into two categories - manufacturing and technological embeddedness. Autio (1997) views the two categories as strategic. Certainly technology can have a strong strategic impact, after all that is the basis of strategic management of technology. Important to this is how it is embedded and used. The importance of a technological compared to a manufacturing embedded firm is the diffusion of technology from the firm. Both however are not mutually exclusive as one can impact on the other. As I discussed in Chapter 2 the use of embeddedness by a firms in its environment is a growing area of research in the area of alliances and from a social network perspective (see Gulati, 1998).

3.5.5 Systematic Uncertainties: Many uncertainties exist in the development of networks especially external or inter-organisational networks. Trust is one of the biggest areas of uncertainty for any firm entering into a network agreement.

> *'Trust is an important lubricant in the social system and has great significance in areas demanding imagination such as innovation'* (Nonaka, 1990: 449).

Information redundancy is viewed in the literature as the means to eliminating deception, cheating and blame. In this way Williamson (1975) sees opportunism as lessened by sharing information within a close, interactive group. The belief is that this information redundancy gives rise to loyal relationships and therefore trust. However, there is a paradox especially in the innovation process, as firms will fear giving up too much information especially that which provides strategic and competitive advantage. Uncertainties can be lessened further. There are many reasons why inter-organisational networks may be successful (Lewis, 1990) but three conditions are vital:

- Mutual Objectives
- Complementary Needs

- Shared Risk

Both partners must be moving in the same direction and must agree on how they monitor and evaluate success or even failure. If this is not done effectively then tensions will mount between the two partners and the overall effectiveness of the partnership and what they aim to achieve will likely fail. This highlights the importance of choosing the right partner, such that both are responsible, reliable and equal in order to foster trust. These uncertainties will also play a part in intra-organisational networks. The right team of actors, with the right complementary assets and competencies are likely to prove important.

These issues regarding the literature have a common thread with the SMOT literature. Firm size being the most obvious of these in relation to research subjects with small firms being dealt with on a limited basis. Also the retrospective view is a common way to examine innovation based on historical data and interviews with people that may have been involved some time ago. Therefore, the research will aim to address these and a number of other issues that cross the two sets of literature. However, I must first identify the way in which networks can be studied. This I believe will aid the development of a framework that can meet the literature problems as well as answering the research questions raised later in this thesis.

3.6 STUDYING NETWORKS

As discussed earlier in this chapter, networks may be viewed as a set of actors connected by links, which represent the type of relationships between those actors identified. Flows will vary in terms of what is transferred and in terms of the value they represent to the network and possibly the organisation as a whole. The biggest issue emerging from this review of the literature is how networks are studied and presented. Networks are more than the sum of bilateral relationships because interactions between firms within the network are iterative and broad in content, time and space, what matters is the complete set of relationships (Mody, 1990). Conway's (1997) definition clearly states the importance of inter-relationships and that network analysis provides a powerful means of understanding but more importantly describing the processes.

> '*.....network analysis is a powerful means of describing and analysing sets of units by focusing explicitly on their inter-relationships*' (Conway, 1997: 1).

Conway (1997) provides a systematic method for revealing and mapping-out the set of actors, relationships and flows drawn upon in the development of a discrete innovation. This framework resolves many of the problems discussed in the previous section. Conway (1997) focused on a number of disciplines to develop a framework or template to examine what he calls 'focal action-sets'. The disciplines include among others sociology of science; innovation studies; organisation studies; and social psychology. Conway's (1997) framework is one of the first to incorporate network theory in relation to innovation and organisation theory in an attempt to represent faithfully the set of relationships in a network and to aid and diagramatically show the links, flows and transactions that are occurring. My aim is to incorporate Conway's (1997) framework with Dodgson and Rothwell's (1991) work to develop a detailed analytical model to study technology management in SMEs. Hence, I will now clearly define the Conway (1997) framework and in Chapter 4 I will examine and develop the integration of the two frameworks identified.

The study and types of networks are inextricably linked to the research question and topic. The literature identifies the key parts of the network to be the actors, links and flows. Again these are defined by the research question. As conceptualised by Mitchell (1969) and discussed in Section 3.2 there are total networks and partial networks (also identified by Scott, 1991). The term actor refers to market and non-market actors. Kamann and Strijker (1991) describe market actors as individual entrepreneurs, firms, SBUs, profit centres, or any units belonging to a corporate centre. Non-market actors are journalists, politicians and lobbies. Interestingly Kamann and Strijker (1991) sub-categorises the actors into the following (Certainly this final category is of interest to this thesis): family and friends, actors related to locational aspects, institutional actors and actors that are specific to the product market combination of an actor and his corporate linkages.

Conway (1997) in his examination of the network literature (Mitchell, 1969; Titchy, 1979; Laumann, 1983; Scott, 1991) identifies important elements to studying networks. Firstly, Conway (1997) identified the attributes and participation of the actors themselves and secondly the manner or way in which the partial network is anchored i.e. around a particular actor or group of actors. The first is known as definitional focus and the second nodal-anchoring (summarised in Table 3.2 - Conway, 1997: 4). The final issue here is how wide the researcher casts their net. A decision must be made to the maximum number of actors not directly linked to the focal actor. It may not be necessary to focus on non-focal actors or the reverse may be true again depending on the research question. Setting the boundaries is important and Laumann (1983) has developed two approaches. The first being the nominalist approach and the second being realist approach. The nominalist approach has its boundaries defined by the researcher and the realist approach has its boundaries constructed by the network actors themselves. The realist approach still incorporated some of the nominalist short falls in that it is still the researcher who decides the criteria for selection of a network to be studied. In both cases the researcher must be careful in analysing the network data and consider possible alternative explanations as well as untapped networks. The work by Conway (1997) suggests that Mody's (1990) statement is applicable and relevant to the networks within the organisations. Understanding a partial network will also require the understanding of the complete set of relationships.

Definitional Focus		Nodal-Anchoring	
Network Type	**Description**	**Network Type**	**Description**
Attribute Network	Inclusion rule based on specified attributes of the actors themselves. Inclusion is based on some commonality.	Socio Centred Network	Focus centred on group of actors within a network.
Transaction Network	Inclusion rule based on actor participation in specified exchange. Transactions may include affect, power, information and goods.	Ego Centred or Focal Network	Focus on single actor within a network. Such networks are personal at the level of the individual. Such a network is based around a friendship or joint venture.
Action-set	Inclusion rule based on actor participation in specified event. Established to achieve some desired end.		

Table 3.2: Summary of Focus and Anchoring of Network Types (Conway, 1997)

3.6.1 Data Collection

The key components of a network are actors, links and flows (Conway 1997). However, as Conway (1997) shows the network literature may be used to build a set of dimensions to aid analysis based on these. In terms of the work by Conway (1997) it is not clear whether qualitative or quantitative data best suits the analysis of networks and in relation to the developed framework although Conway (1997) used a qualitative approach. The variables upon which the data may be collected fall into three inter-related but distinct categories which include actor variables, relationship variables and transaction content variables.

The actor variable is the unit of analysis and relates to the actors in a given dyad. Such actors may be individuals or virtually any aggregation of individuals, such as a group, an organisation, a community, or even a nation state. The actor type will be pre-set by the researcher and the questions/hypotheses to be answered by examining the types of actors.

Relationship variables are a broad range of relationship variables which can be identified by examining the literature. The variables identified by Conway (1997) examined regarding relationships include relationship type, formalisation, intensity, reciprocity, multiplexity, and origin.

- Relationship type which relates to the way in which a dyad may be described in terms of the nature of the tie (Kanter, 1972) or bond (Hakansson and Johanson, 1990) which maintains the relationship. Committed Communities; Instrumental-Ties (through which mutually rewarding economic exchanges can be operationalised); Affective-Ties (through which satisfying emotional sentiments, such as friendship, can be evoked); Moral-Ties (where code of fairness, social banking and reciprocity, are the main building forces).
- Formalisation of the relationships. Formal recognition between actors are often contractual in the most formal of relationships however informal relationships can also play an important role in the relationship and its effect on the action set being researched.
- Intensity is a variable that identifies the strength of link by identifying the frequency of interaction and flow of transaction content.
- Reciprocity: Balance and flow over time of transaction content through a given linkage (asymmetric or unilateral) and the flow is symmetric or bilateral.
- Multiplexity: Identifies the degree to which multiple role relations (Tichy, 1979) link two actors.
- Origin: Identification of the events leading to the linkage - Initiator and context

Transaction content variables are tied to the type of transactions and what in fact is being transferred between individuals and groups of actors in the action set. There are sub variables and these include transaction content types. These identify the content of transactions and aid identifying dyadic relationships (Conway, 1997: 9). Content Types may include affect (the exchange of friendship); power (the exchange of power and influence); information (exchange of ideas, information and know-how); goods (exchange of money, technology or services). Role aims to identify how the content of the transaction is linked to the activities within or around the action set. Finally exchange value or utility which looks for the perceived value to the actors of the exchange content. The exchange value may equate to that value which is perceived through receiving or transmitting through the relationship.

3.6.2 Mapping Networks

Important in analysing the network once data has been collected is the representation of the network either descriptively or graphically or in combination. As stated earlier, in this area, network presentation has been loosely dealt with and certainly not considered as important as gaining the data. This is understandable in the sense that if the data is correct then how it is to be represented can be dealt with later. However, the picture can be misleading or be incorrectly perceived and misunderstood if there are no clear rules. The Conway (1997) framework provides a user tool that addresses many of the issues and disjointed graphical representations the literature currently offers. The importance of Conway's (1997) *'Actor Positioning Template'* (Figure 3.2) is that it maps the firm and its internal and external inputs and allowing the individual actors in a network to be placed on it. The resulting map represents the actors' inputs, outputs and interactions in the network.

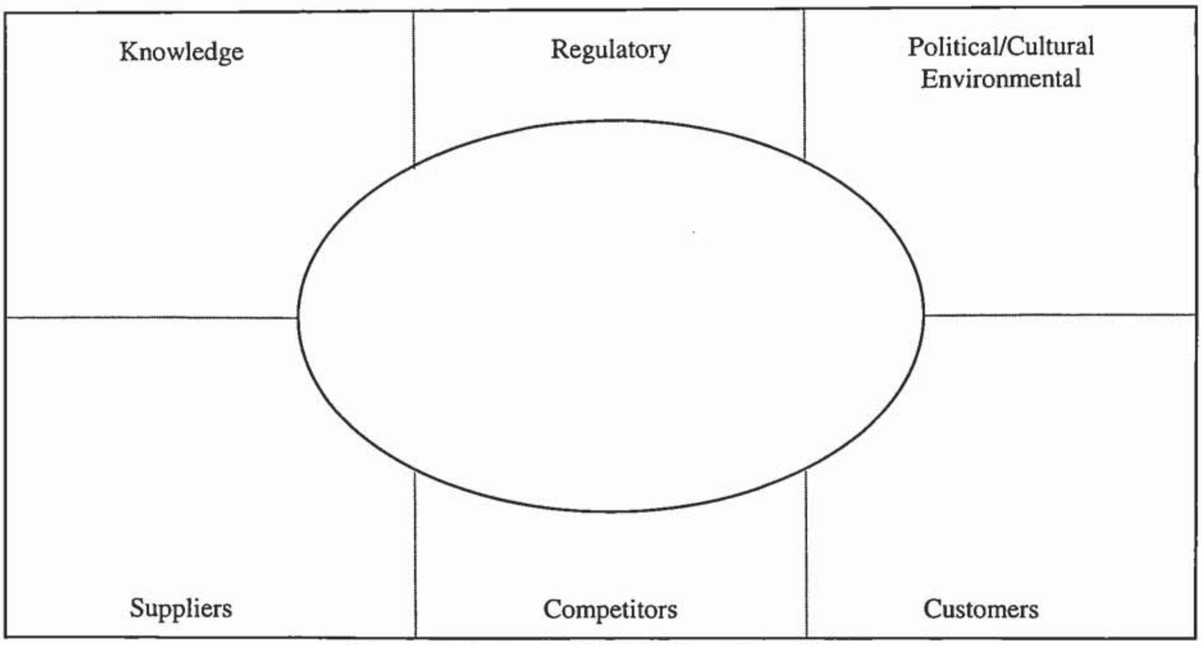


Figure 3.2: Actor Positioning Template

The framework was developed on the basis of a number of generic characteristics of successful technological innovation and these were:

- multiplicity of inputs into a single invention or innovation
- diversity of inputs (different types i.e. tacit knowledge or technological artefacts)
- multiplicity of internal and external sources of input
- diversity of external types of actors
- diversity of internal types of actors
- diversity of actor scale (e.g. individual, group, function or organisation)
- diversity of relationship types (e.g. formal agreements or informal interaction)

> *'The template allows for the representation of both internal and external interactions simultaneously, with intra-organisational dyads being confined to within the ellipse, and inter-organisational dyads being located in one of the five outer segments of the graphic, depending on actor-type'* (Conway, 1997: 7).

The representation allows the possibility of analysing the innovation network at three levels:

1. the individual dyads that make up the action-set
2. the overall morphology of the action-set
3. the manner in which the action-set is embedded in its environment

Conway (1997) identified from work by Bertin (1983) what he calls 'a range of visual variables' to represent the characteristics of the actors, relationships and flows that are of particular relevance to the innovation process and the study of innovation networks. The visual variables range from nodal shape to line shape. The variables are summarised in Table 3.3:

Variables	Description	Visually
Nodal shape	encapsulates the diversity of actors	Firm Individual
Line texture	broken or solid denotes formal or informal links and therefore the nature of the relationship	Formal Informal (Instru) Informal (Affect)
Line size	width of line denotes the intensity of interactions and exchange	High Medium Low
Line shape	arrow heads show the direction or flow of transaction content	One Way Two Way

Table 3.3: Summary of Visual Variables (Conway, 1997)

These mapping conventions or variables are changeable in the sense of the use of colour for the lines to denote transaction types/content or using colour (not done in the Conway, 1997 template) in relation to nodal shapes to highlight relative importance in relation to the action-set. In my opinion the most important conventions are the line texture, size and shape. The development of a colour convention would also, when viewing the maps, show the types of transactions. Conway (1997) also in his framework identifies a number of dimensions on which the network may be analysed. These are size, diversity, stability, centrality, openness, and shape taken from work by Tichy (1979), Burt (1983) and Auster (1990). Size simply refers to the number of actors participating in a network (Tichy et al, 1979). It should be noted that this size is often arbitrarily set by the boundary set by the researcher. Diversity refers to the number of differing types of actors in the network and the number of different types of linkages. Stability acknowledges the degree to which a network pattern changes over time (Tichy et al, 1979: 508). Auster (1990) also refers to the frequency and magnitude of change of the actors and linkages in a given network. Centrality is defined by Tichy et al (1979: 508) as the degree to which the formal hierarchy guides relations. What this equates to is the proportion of the links in the network that may be viewed as formal. Openness again defined by Tichy et al (1979: 508) as the number of actual external links in a social unit. That is the number of links between a given network and other networks. Finally shape comes from the fact that the template provides an opportunity in positioning the actors to analyse the shape of the network or focal action-set. This is especially so in relation to the spread and balance of the linkages to actors with various segments. The example given by Conway (1997) is that a research orientated organisation is likely to link more strongly to the 'knowledge' segment while market orientated organisations would be expected to have stronger links to the 'customer' and 'competitor' segment.

3.7 CONCLUSION

In this chapter I have identified many of the ways in which networks are defined, examined network types, and discussed the problems and benefits of network analysis. In surveying the literature I have been able to identify how a researcher may examine, research and map networks at varying levels. However, the question remains, what can all this add to the Strategic Management of Technology (SMOT) literature given the quote upon which I ended the introduction to this chapter:

> *'.....the network approach has something original, useful, and durable to bring to innovation studies...........the concept of network may provide a bridge between disciplines'* (DeBresson and Amesse, 1991: 363).

As discussed, Conway (1997) provides a useful tool to map and aid the understanding of networks between actors. The tool utilises graphical representations to assist in the examination and understanding of the networks being researched. Hagedoorn and Schakenraad (1992) view the graphical representation of networks as enabling the identification of 'concrete networks' and the 'major companies involved'. The graphical approach (Conway, 1997) incorporated with explicit mapping conventions provides a well-defined means to identifying 'concrete networks' and more specifically mapping major actors involved. Conway (1997) states that networks can be used to represent structure of personal and organisational relationships, flows of information, technology, goods, money, power and friendship. In this way they can reveal network size, network density (groupings and gaps), diversity, openness, key actors and changes in these characteristics over time. This final revelation suggests a potentially important aspect of the strategic management of technology can be examined. Utilising the network approach outlined allows the researcher to track the movement of technology, information and knowledge between internal and external actors and organisations. By incorporating this with the strategic management of technology framework based around the key elements of developing technology (technology strategy) at the strategic level (corporate strategy) suggests that we can map the networks of a particular innovation action set over time. In doing so we are able track the relationships within the networks chosen (abstracted). As they evolve or not the relationships can be mapped. Therefore, the possibility is there to examine, map and analyse the networks that are generated in a firm's attempt to achieve competitive advantage or to innovate. In this way we can also view how the innovation process is shaped and defined including the precursors, processes and outcomes associated with the strategy and networks utilised.

- what external and internal networks should the firm develop to achieve the objectives of its corporate and/or technology strategy?
- do networks vary with strategy?
- do the networks vary with types of technological developments?

The research methodology will be key to answering the questions raised in this chapter and Chapter 2. The research strategy and framework to be developed should provide the basis to meet the limitations of the literature identified in both chapters.

Chapter 4:
CONCEPT INTEGRATION

CHAPTER 4

CONCEPT INTEGRATION

4.0 INTRODUCTION

In the previous two chapters I identified the key concepts and theoretical perspectives of the strategic management of technology and networking focusing on innovation and technology. From the later discussions in Chapter 2 it is clear that networking plays a major role in the strategic management of technology and the innovation process. The framework developed by Dodgson and Rothwell (1991) states the importance of networking in the strategic management and innovation process. Although undeveloped from a network perspective the framework has potential for development (Jones and Beckinsale, 1994). The examination of the network literature identified a framework developed by Conway (1997) to examine and map innovation networks. The question for this chapter is - can these two frameworks be integrated to clearly develop a strategic management of technology framework with a network perspective? The contribution of such a framework would be in providing a dynamic analysis of changing relationships, strategies and objectives during the introduction of new technologies and the innovation process. My intention is to integrate Conway's (1997) network template with the SMOT framework developed by Dodgson and Rothwell (1991). Integrating the two concepts outlined in Chapter 2 and 3 may at first sight seem unlikely because the Dodgson and Rothwell (1991) framework is prescriptive whereas Conway's (1997) framework is an analytical template. In order to achieve integration I firstly identify the variables of the Conway (1997) framework. Secondly, I compare the framework's variables and highlight the common links between the two. Thirdly, I examine the Dodgson and Rothwell (1991) framework in more detail. The SMOT concepts that underpin each of the five factors are examined in detail to identify the total set of potential network variables. Fourthly, each of the Dodgson and Rothwell (1991) factors are summarised in terms of the identified network variables that fit the actor, relationship and transaction variables of Conway's (1997) framework. Finally, in basing the integration on the respective variables and theoretical positions of the frameworks means that the Conway (1997) template is re-examined. I develop the actor positioning template to incorporate key elements of Dodgson and Rothwell's (1991) framework. The developed template is called the Strategic Innovation Network (SIN) and will be used later in the thesis.

4.1 IDENTIFYING AND COMPARING VARIABLES

Both frameworks are based on an examination of the technological and innovation process. The Conway (1997) model provides a defined set of variables to collect and collate information relating to the examination and analysis of networks (focal innovation action-sets). Each factor in the Dodgson and Rothwell (1991) framework (Accumulated Technological Competencies; Internal Strategic Cohesion; Organisational Specialisms; External Orientation; and Management Skills) is based on specific influences on the innovation process. These influences being competencies, external links, internal links, management and the organisation's embeddedness in its environment and markets. Table 4.1 shows the specific variables in the Conway (1997) framework. These variables are defined in Chapter 3 and were developed by academics such as Kanter (1972), Hakansson and Johanson (1990) and Tichy (1979).

Variables Categories	Actor Types	Relationships	Transaction Contents	Other Variables
Sub-variables	**Knowledge** **Supplier** **Customer**	**Formalisation** (extent of formal recognition) **Intensity** (strength and frequency of interaction and flow of transaction content over time) **Reciprocity** (balance and flow over time of transaction content unilateral or bilateral) **Multiplexity** (the degree to which two actors are linked by multiple role relations) **Origin** of link	**Transaction Types** **Exchange Value or Utility**	**Size** - number of actors in the network **Diversity** - number of different actor types and linkages **Stability** - the degree to which the network changes over time **Centrality** - degree to which the relations are guided by the formal hierarchy **Openness** - links between a given network and other networks **Shape** - spread and balance of linkages

Table 4.1: Conway (1997) Network Framework Variables

The Conway (1997) variables fall into three specific categories (actor; relationship; and transaction) with a fourth category based on more general variables that inform the overall network. It is on the basis of these four categories that the Dodgson and Rothwell (1991) framework will be analysed. Before I examine in detail the Dodgson and Rothwell (1991) factors and variables the following section puts the variables in the context of the Conway (1997) framework's four levels of variables.

4.2 COMPARING VARIABLES

Actor type variables: The Dodgson and Rothwell (1991) framework views actors as having both an external and internal relevance to the strategic management process. External actors are seen to play a role in the following factors: external orientation and accumulated technological competencies whereas internal actors play an important role in: internal strategic cohesion, organisational specialism and management skills. The actor variables are more specific in terms of their utility where as the network template actor variables are more generic in terms of encompassing a wealth of possibilities. In comparing and therefore matching the variables, the Dodgson and Rothwell (1991) variables favour the idea of knowledge actors, supplier actors and customers in terms of accumulated technological competencies and external orientation.

Relationship variables: The Conway (1997) framework identifies a number of relationship variables including formalisation and intensity. In the same way the Dodgson and Rothwell (1991) framework clearly identifies formalisation as a key variable in the strategic decision-making process. Intensity is also viewed as a key variable in the internal strategic cohesion factor. Intensity is identified as an aid in communication and information flows within the internal strategic cohesion factor. Reciprocity is a relationship variable that deals with the direction and flow of the transaction. The two factors pertaining to accumulated technological competencies and external orientation relate to reciprocity in terms of the content of transactions. The types of transactions impact on the relationship and the reciprocity. The network framework is more general in terms of relationship types where as the Dodgson and Rothwell (1991) framework defines specific types such as joint ventures and collaboration. These are however not exhaustive.

Transaction contents: Transaction types in terms of the Dodgson and Rothwell (1991) variables relate to competencies, knowledge, technology and information (general and strategic). The factors that examine transactions are: accumulated technological competencies; external orientation; and internal strategic cohesion. The network framework identifies transaction types as affect, power, information and goods. These equate strongly to the

Dodgson and Rothwell (1991) transaction variables with goods relating to technology and information being the same in both. The exchange value and utility relate to accessing technology to benefit competitive advantage as well as know-how and strategic information. The value and utility is geared towards competitive advantage and strategy. The network framework is also directed towards such value and utility variables as innovation can provide competitive advantage through accessing technology and know-how.

Other variables: The Dodgson and Rothwell (1991) framework identifies the significance of firm size. Firm size plays an important role in the strategic management of technology in relation to communication and information flows. The organisation as a whole is a network of actors and the size of the network as well as specific action sets play a key role in communication and information flows. Although diversity is not specifically incorporated in the framework the variable of integration is key. The wider and greater integration between actors and department the better the flow of information. This is most specific in relation to internal strategic cohesion and accumulated technological competencies. The shape variable identified in the Conway (1997) framework relates to the structure of external linkages whereas in the framework shape is identified as 'architecture' however this relates to internal structures. This I believe is a key area for development in the Conway (1997) framework and template. The external orientation factor has a more significant and obvious link to shape in the network framework. Openness is identified in both frameworks as important to the benefit of innovation. Finally although not specifically identified in the network framework, are skills which play a part in the roles of individuals/actors in the innovation process. In comparing the variables we can start to see where particular factors from the Dodgson and Rothwell (1991) framework connect or simply relate to the network theory underpinning the Conway (1997) framework. The network variables clearly cross the boundaries of the SMOT factors and the following sections support this point.

4.3 FRAMEWORK VARIABLES

The following sections examine the five factors in Dodgson and Rothwell's (1991) framework (Chapter 2). The examination utilises SMOT tools and theory to highlight the areas through which the variables fit and underpin each individual factor. The following section examines the individual factors more closely and in detail to aid the identification of the variables and then in section 4.4 these will be discussed in terms of the links between the factor variables and the network variables in order to finally develop the framework. Table 4.2 outlines the theories and models that relate to the five individual factors.

Factors	Related Concepts
Accumulated Technological Competencies	Competencies; Complementary Assets
Internal Strategic Cohesion	Communication patterns; Committees; Rules and Procedures
Organisational Specialism	Organisational Structures; Structure in relation to environment; embeddedness of businesses in environment.
External Orientation	Licensing agreements; joint ventures; accessing conferences, information from regulatory bodies and government. Marketing, Customers, Suppliers.
Management Skills	Forecasting; Procedures, Project Management; Audits, Technology Types; Life Cycle Models.

Table 4.2: The Five Factors and SMOT Tools and Concepts

4.3.1 Accumulated Technological Competencies (ATC)

ATC's are based on the expertise, knowledge, resources and skills required to successfully meet threats and opportunities of technological change. This factor offers the first link in acquiring knowledge, technology and expertise from external sources. Teece (1997) points out that core competencies are often confused with core technologies or capabilities and the latter are core components of core competencies. Obtaining and accessing complementary assets and competencies has an important role in innovation and the Strategic Management of Technology.

> *'Complementary assets and competencies are an essential part of the innovation process and a lack of assets will likely lead to failure as will limited assets'* (Prahalad, 1997: 176).

Competencies (Prahalad and Hamel, 1990): Core competencies can be thought of as consisting of bodies of technological expertise (both product and process) and the organisational capacity to deploy that expertise effectively (Coombs, 1994: 2). They also represent the collective learning in the organisation especially how to co-ordinate diverse production skills and integrate multiple technology streams. Core competencies are communication, involvement, and a deep commitment to working across organisational boundaries. World-class research in, for example, lasers or ceramics can take place in corporate laboratories without impacting on any other business areas of the company. The skills that together constitute core competence must coalesce around individuals whose efforts are not so narrowly focused that they cannot recognise the opportunities for blending their functional expertise with those of others in new and interesting ways (Prahalad and Hamel, 1990). As Prahalad (1997) states it is the creative bundling of multiple technologies and customer knowledge and intuition, and managing them as a harmonious whole.

Unlike physical assets, which do deteriorate over time, competencies are enhanced as they are applied and shared. But competencies still need to be nurtured and protected; knowledge fades if it is not used. Competencies are the glue that binds existing businesses and are viewed as the engine for new business development. They may guide patterns of diversification and market entry, not just by the attractiveness of markets. When identifying competencies we should note that technology is not competence as it can be stand-alone. Competence is embedded in the whole organisation is recognised as tacit knowledge, explicit learning and is often the cumulative knowledge base involving a large number of people is critical. Identifying core competencies is achieved through what Prahalad (1990; 1997) identifies as a three-step process.

1. Providing access to a variety of markets
2. Enhancing 'perceived' consumer benefits
3. Difficult for competitors to imitate

Prahalad (1997) went a stage further and explained and defined these stages by way of a number of tests. The test utilised questions that needed to be answered and depending on the answers the competencies could be identified:

(1) Is it a significant source of competitive differentiation?
(2) Does it provide a unique signature to the organisation?
(3) Does it transcend a single business?
(4) Does it cover a range of businesses, both current and new?
(5) Is it hard for competitors to imitate?

Prahalad (1990) gave examples of competencies by examining cases such as the Sony Corporation, Casio and NEC. Prahalad (1990) identified among Sony's competencies miniaturisation. To bring miniaturisation to its products, Sony had to ensure that technologists, engineers, and marketers shared understanding of customer needs and of technological possibilities. The force of core competence is felt as decisively in services as in manufacturing. Citicorp was ahead of others investing in an operating system that allowed it to participate in world markets 24 hours a day. Its competence in systems provided the company with the means to differentiate itself from many financial service institutions.

Although there is a technology component in identifying and understanding competencies Prahalad also identifies the importance of the governance process inside the organisation and collective learning. The governance process is based on the quality of relationships across functions and business units and the collective learning is across levels and function within the organisation. This is important and interesting from the point of view of the ATC factor in that organisation networks play a role in the development of competencies both formally and informally.

Complementary Assets (Teece, 1997): These assets (Teece, 1997) play a major role in commercialising the innovation whether a product or process. Innovation consists of technological knowledge about how to do things better than the existing state-of-the-art. That knowledge is codified and tacit. To commercialise an innovation - the knowledge must be utilised in conjunction with other assets in the firm - manufacturing, marketing, and service. These complementary assets can be divided into three categories:

Generic	**General-purpose assets not tailored specifically to the innovation.**
Specialised	**Unilateral dependence of asset on innovation or vice versa.**
Cospecialised	**bilateral dependence (e.g., Mazda and their rotary engine - needed to establish repair facilities -two-way dependence**

Table 4.3: Assets and their Dependence - Teece (1997)

Examples include (Teece, 1997): co-specialised assets might be repair facilities needed to support the introduction of a new car engine; generic assets might be the manufacturing facility needed to make running shoes; specialised assets might include the repair facility. However, interdependence between the Innovator and complementary assets may vary considerably. Example of co-specialisation - containerised shipping requires special trucks and port facilities (not suitable for other methods of shipment). Such assets can be owned or rented. Ownership is often seen a greater benefit as the firm is a position to benefit and capture the spill-over benefits stemming from increased demand for the complementary asset(s) caused by the innovation. Resources, control, risk, timing and size can play an important role in a firm's decision to rent or internalise assets. Teece (1997) argues that a technological leader is more likely to internalise assets whereas imitators are more likely to rent or license hence again why a leader can benefit from spillover benefits. Complementary assets again like competencies involve the use of networks to provide and make the most of the assets required. The renting of assets will require a firm to be aware of its external environment and to know where required assets can be obtained/rented. However, the internalising of assets will add a new dimension to the organisation involving new learning and knowledge and generating a new internal network in the organisation to support the innovation that it depends on. In either case of renting or internalising the assets will nearly always need to be used in conjunction with other capabilities or assets. Services such as marketing, competitive manufacturing, and after-sales support are almost always needed. These are often specialised assets.

4.3.2 Internal Strategic Cohesion

This factor is important in the strategic management of technology because it is interaction between actors that leads to a high level of internal strategic cohesion. The flow of information is a key part of this factor especially the flows of information from the networks to the strategic decision makers and vice-versa but also, as stated by Coombs, et al (1987) between departments/functions. It is clear from the literature that the digesting and classifying of information must be efficient so that effective communication, in the innovation process, can play its important role, and it is the need for effective communication which faces R&D managers, innovation managers and strategic managers. As De Meyer (1991) points out, it is hard enough to keep communication flowing in one function/department let alone all functions in the organisation. Because companies are now entering into varying forms of networking to stimulate innovation and research and development they require mechanisms to both stimulate communication and improve co-ordination. Therefore, communication is not only required within a single function/department but also the various other units of the company with the centre. Good, open communication is required between managers and staff. So ways of stimulating communication between individuals and groups are needed.

Many studies of R&D (see Allen 1977; De Meyer 1985) have shown that the innovative capacity of a firm and the productivity of its researchers and R&D engineers depends largely on the ability of all parties to tap into appropriate networks of information. Gatekeepers in an organisation perform an informal but crucial function in this and should involve individuals that are highly technical performers and able to interact harmoniously with others (Jain and Triandis, 1997: 31). De Meyer (1991: 49) states that *'proper communication pathways are essential to innovation'*. A common characteristic of an innovative firm, group or individual is the open and rapid communication between research groups and management at all levels, informally between R&D professionals and informal presentations to senior management. Parent companies need to know precisely what is occurring in overseas R&D facilities so that the strategic implications can be assessed and research effectively exploited. Important are the systems and mechanisms that provide a link between the board and strategic decision-makers with the project teams and R&D. Mechanisms include formalised meetings with the inclusion of board members, the formalisation of meeting notes that are passed onto the board.

Figure 4.1: A Simplified Model of the Relationship Between The Innovating Firm and its Environment (Coombs et al, 1987:10)

The flow of information is a key part of this factor especially the flows of information from the networks to the strategic decision makers and vice-versa but also, as stated by Coombs et al (1987: 10) between departments/functions. The model in Figure 4.1 is a simplified model of the relationship between the innovating firm and its environment. As stated by the authors 'the model does not pretend to any analytical status, it is simply an aid to describing the main environmental factors which contribute to innovation decisions, and the principle departments of the firm which participate in them.' (Coombs, et al 1987: 10)

Coombs et al (1987) emphasise the importance of the corporate plan/strategy whether explicit or not in influencing the interactions between the functions and departments and actors in an organisation. De Meyer (1991), Humbert (1993) and Fourcade (1993) outline organisational requirements to stimulate communication and interactions. All suggest structural changes within the organisation and in the units. For example, the setting up of committees, developing networks between the communicating parties and possibly the setting up of a central R&D staff or group.

Committees: In the conduct of research work related to a project whether it is orientated toward a technological end or purely an interdisciplinary scientific enquiry must be co-ordinated by a formal committee structure. This is necessary both at the level of the laboratory and at the level of the whole company. A committee within the laboratory is required for the cross-fertilisation of ideas between all the contributing groups. At the corporate level, a committee may involve senior management from the corporate body, marketing and production management and research directors from all laboratories plus others.

Network Organisation: A generic definition views networks as an organised combination of relationships and Fourcade (1993) states, the network is a sphere of relations, a sphere of innovation and a sphere of strategies. Therefore, each person involved in the network is supposed to 'act as a node' in a network of equals (i.e. R&D directors), relaying messages between the different laboratories at all levels. If messages are sent, then there is unlikely to be any preferred route. Networks aid verbal communication, which plays an important role in R&D activities (Jain and Triandis, 1997: 29). The relationship is therefore, both social and an interactive one between groups and individuals.

Central R&D Group: This is likely to involve a central co-ordinating staff that will have explicit communication responsibilities. De Meyer (1991) found that the specific task of central R&D was to co-ordinate activities and to stimulate communication. The staff tended to act as monitors of information movement with the added responsibility for managing the exchange of information and the communication process within the R&D facility.

De Meyer (1991) and Humbert (1993) also identify the following mechanisms: socialisation - which can involve the use of temporary assignments and travel to stimulate a positive culture; rules and procedures - emphasising careful reporting and documentation; planning procedures - used to stimulate communication between individual laboratories; and assigning individuals to facilitate communication flows - individuals are likely to have strong contacts within other laboratories and will be capable of translating information gained into his/her own laboratory.

Internally, individuals and groups must communicate and face-to-face communication is cited as the most efficient (De Meyer, 1991). Face-to-face contact is the backbone of an efficiently operating information and communication network. To exchange information, the parties have to talk to each other and in the case of an alliance understand and identify with one another. Further information, which may also be shared, can come from external sources. There is always the need to keep watch on what ones competition is doing and what is new in the field (White, 1976). Old and new technology may prove valuable in communication process. Electronic communication can, and is, replacing the need for communicating parties to be in the same room, building, town or even country.

4.3.3 Organisational Specialisms

Organisational specialism is a development of the internal strategic cohesion factor. However, it is a wider examination of the organisational structures that allow general communications to flow functions to operate as well as strategic information to be passed to the relevant sources. There is a paradox within organisations given the need to specialise functions such as R&D and marketing and yet needing to co-ordinate these specialised functions with other functions to achieve the corporate goals. As the strategic management of technology literature (Dussauge et al, 1987) as well as the organisational literature (Lawrence and Lorsch, 1967) points out functional specialisms can reflect the way individual members view the organisations environment, the differences in members and the difference in the way tasks are achieved. As Dodgson and Rothwell (1991) state architecture, openness and systems are important. The SMOT literature offers some forms of structure and systems that could meet the difficulties of organisational specialism. Examples include technology cluster structures that involve largely autonomous units becoming operational units of the company (Dussauge et al, 1987). The technology involved in each unit is a key element of the central firms core businesses; Co-ordination structures in which no single element of the relationship has a dominating position. Such a structure means the co-ordination of different teams working on the same problem. The benefit being that with good co-ordination duplication of tasks can be avoided. Ideas can be pulled, although this does carry considerable co-ordination costs. Interfirm structures (Interfunction/business?) offers a specific structure responsible for a project. Skunkworks are the development of projects which are not 'officially' approved, whilst still using R&D budget the individual or team does not report to the hierarchy and is extremely autonomous (see Peters and Waterman, 1982; and Kidder, 1981). Finally the matrix structure (Burns and Stalker, 1961) combines an organisation structured by function with an organisation structured by product or division. Such a structure eliminates the problems of differentiation and integration of functions (Lawrence and Lorsch, 1967) but can create difficulties between the two axes on the matrix i.e. a functional and product manager.; New ventures department (NVD) is a structure to foster more fundamental innovation (Dussauge et al, 1987). Usually this is located at the corporate level, separate from other product divisions or central R&D. The purpose is to identify, sponsor, and commercialise new products. It is possible to achieve this internally or to enter into joint ventures, venture capital investment, spin-off product ideas, or license technology to outside parties.; and independent business units are units set up which draw upon technological resources at the corporate level, whilst established with their own identity, strategy, structure and formal systems. This can produce a very different model of management that is in contrast to existing practices in the firm, which may mean the transferring of people, and knowledge is problematic. None of these options are perfect but offer choices to how best organise structures to foster technology, invention and ultimately innovation.

4.3.4 External Orientation

For a firm developing a new product or process the activity can be of high risk. Such activity requires the commitment of a large proportion of investment funds along with committing time and resources to the particular activity. Lessening the risk is of central importance to small and large firms entering into such an activity, but perhaps is most crucial to small firms which have fewer resources (Dodgson, 1989). Strategies can be adopted to increase technical manufacturing, market and managerial know-how through engaging in external technical and other linkage activities.

> *'Changes in external forces translate into changes in consumer demand for both industrial and consumer products and services'* (Dodgson, 1989: 114).

This factor is a key element in understanding the ways in which a firm can be aware of changes in the environment. A firm may be able to access technology by orientating itself around its market, consumers, suppliers, customers, regulatory bodies, government bodies, universities and trade fares/conferences (Dodgson, 1989). Activities include entering into licensing agreements and joint ventures as discussed earlier but possibly more importantly accessing conferences, information from regulatory bodies and government. Changes in European law and environmental regulations have impacted on many firms over the last 10 years and being aware of future changes can provide a firm with the information which can set in motion a plan to avoid the disadvantages of such changes. The SMOT literature places great emphasis on the use of external bodies to assist in the access of knowledge, technology and ultimately to aid in developing inventions and long term innovations (Tidd et al., 1997; Dussauge et al, 1987). A firm with good external orientation can better prepare for changes in external forces and therefore plan for change. The literature identifies a number of key roles that involve external linkages and are required to complete a project successfully. Roberts and Fusfeld (1981) identify five work roles, many of which operate both internally to the project team but also externally to the organisation. The five work roles are:

- idea generating (developing and idea for a new product or procedure)
- championing (gaining formal management support for the new idea)
- project leading (co-ordinating the activities and people necessary to develop the idea into a product)
- gate-keeping (collecting outside information and channelling it into the team)
- sponsoring (providing resources and support for the project)

Developing networks is a key part of providing a firm with an external orientation (DeBresson and Amesse, 1991; Freeman, 1991; and Gulati, 1998). The benefits to a network and possibly the organisation in developing a broad external orientation is in the potential for gaining technological expertise (Dodgson, 1989). Such that the firm can acquire know-how, feedback from users and suppliers (may include prototype testing with potential customers) and reduce risk because of the demands and costs of developing new technologies. External bodies can prove an important factor and may include universities; research institutes; suppliers; customers; licensing agreements and even strategic alliances.

4.3.5 Management Skills

The development of technology for strategic purposes requires managers to be skilled in the planning, auditing and identifying of technologies which may impact on the firms' current and future products and processes. The demands on managers include technological assessment, building and obtaining benefit from collaborative links, and integrating these with external expertise (Dodgson and Rothwell, 1991). This implies that networks are key to the management of new technology. There are a number of tools and skills that aid in assessing current technologies and future technologies and managing the role in terms of aiding potential innovation. These tools are: technological forecasting; technological audit; inventoring technological assets; mapping technology types; life cycle models; technology portfolio; and managing the innovation process.

Forecasting is the analysis of technological trends used in the formulation of a technology strategy (Dussauge et al, 1987). Various forecasting methods have been developed to predict future technological change and trends. Some are based on the extrapolation of past trends whilst others entail the use of scenarios. The extrapolation methods take already existing technologies and aim to find out how they might change in the future given certain conditions and these usually work best over the short term (up to 5 years) or within a specific time frame. Such techniques provide a quantified evaluation made on the basis of past trends. The scenario methods are more long term (10+ years) and tend to be used to develop a picture of the future of technologies without constraints. The aim is to formulate of a set of alternative futures and the evaluation of their impact on the company. It envisages all possible future technological trajectories taking into account past trends plus all those involved. These forecasts can be drawn up using, and on the basis of, expert opinion. It allows the forecaster to incorporate technological discontinuities and changes not evident from using past and present trends. The final outcome will be a number of potential technological trajectories thus allowing for the elaboration of multiple futures and examining their individual consequences on and for the firm. Forecasting can be advantageous in terms of identifying how and when technological change will enhance performance and may provide insights into the impact of a technology socially, competitively and environmentally. However forecast methods tend to emphasise quantitative variables which are predictable and quantifiable and generally avoid qualitative variables. Yet qualitative variables are often an essential consideration in management. Forecasts are restrictive as they tend to put more emphasis on the quantifiable and once forecasts are made the results are often viewed whilst overlooking the assumptions and circumstances underlying them. They also fail to consider technological discontinuities that alter past trends and effect the extrapolation process.

Technology forecasting can assist business decision-making in a number of ways: wide surveillance of the environment helps identify developments within and outside the normal sphere of activity; estimating time scales for important events - in relation to the company's planning horizons - indicating urgency for action; monitoring trends - while not of immediate consequence a variety of trends must be kept under review; and re-orientation of company policy to avoid threats and to take advantage of new technological opportunities. Finally there is the improving of operational decision-making - particularly in relationship to: R&D portfolio; R&D project selection; resource allocation to projects; investment; and recruitment. The literature (Twiss, 1995: 293; Berry and Taggart, 1998: 887) suggests that technology forecasting is only appropriate for companies with sufficient resources and is therefore difficult for the majority of small companies.

Technological Audit: The strategic management of technology goes beyond the anticipation of technological developments and is the determination of how a technology can be used to create a competitive advantage. For this reason it requires both the firm's technological environment and technical capabilities to be taken into account (Dussuage et al, 1987). Therefore, decisions regarding technology must be integrated into the overall strategy formulation. The technology audit enables the firm to manage the development of its technological assets strategically. This requires not only the identification of the firm's competencies in technologies but also what competencies should be acquired. Before a firm can select the technologies it requires, it must inventory the technologies it already has. In doing so it should assess the strengths and weaknesses of these.

Inventoring their technology provides the firm with a picture of its technological assets. It is often difficult to determine the degree of detail required for dividing the firm's capabilities into technologies. It therefore requires those who are identifying the technologies to work in collaboration with those units that implement such technologies (Dussuage et al, 1987). Such an inventory can provide a number of advantages other than simply identifying all technologies used by the firm and its individual businesses. It can reveal some of the technologies that the businesses requires but as yet does not have also revealing potential applications for a firm's technologies (may help to develop synergies in technologies across business units). Using the inventory as a comparison with competitors can provide a firm with a way of looking for weaknesses in its competitors technological base and highlight gaps in the firms own technologies relative to its industrial competitors.

Technology Types	Competitive	Investment
Base	Low impact	Low investment required - divestment common
Key	High impact on product and manufacturing performance. Key technologies mature so competitive edge may reduce.	High investment
Pacing	High impact. Pacing technologies replace key technologies. Can change or create new industries.	Selective but often high.

Table 4.4: Summary of Technology Types (A D Little, 1981)

Once the technologies have been identified they then need to be categorised into competitive impact. Not all technologies will provide competitive advantage and therefore individual technologies will affect cost-leadership and differentiation strategies to varying degrees (Dussuage et al, 1987). The benefits may be reduced due to the fact that the competition has a similar technology or it can be increased when the technology is unavailable to the competition (Dussauge et al, 1987). The consulting firm, Arthur D. Little (1981) classifies technologies providing a static image of the firm's situation into the following three categories (base, key and pacing) these are summarised in Table 4.4:

Life Cycle Models (Dussuage et al, 1987): (Product Life Cycle, Technology Life Cycle and S - Curve) are a useful guide to resource allocation both at the product level, industry level and the technology level. These give the audit a dynamic perspective.

Technology Portfolio: A technology portfolio has the aim of providing an overall diagnosis of the firm's technological situation (Dussauge et al., 1987). Technologies used by the firm are positioned in a matrix with dimensions that reflect its technological assets in a strategic perspective. The matrix is built on the following two dimensions:

1] the competitive impact of each technology

2] the firm's position in each technology

Figure 4.2: Technology Portfolio (Pappas, 1984)

By positioning the firm's technologies within this matrix (see Figure 4.2) provides a way of evaluating technological assets. It also, by comparison with the business portfolio provides information on the long-term sustainability of the firm's strategic position. It is also possible to see which products or businesses the firm's technologies are used by through relating the technologies to the businesses and products. Shared technologies can be identified, along with those that are specific to a business or to a product. Using the technology portfolio analysis provides the direction the firm's strategy is moving in. These can usually be classified into two broad strategies: a product or market oriented strategy; and a technology based strategy

Managing the Innovation Process (Dussuage et al, 1987): Two broad methods can be used to manage the innovation process. These are creativity and value analysis. Creativity requires methods such as brainstorming to stimulate the capacity and vision of management to articulate alternative futures within a group process deliberately ignoring all constraints. Thus identifying potentially radical technological changes. Value analysis may be used to induce technological innovation. This requires an in-depth analysis of all component parts in a product and their individual costs. By examining each part individually and in detail including the materials it's made from, finishing, labour and supplies, possibilities for improvements and cost reductions may be found. This can help to focus the R&D effort and develop project ideas that may have an impact on competitive advantage. Thus helping to identify and evaluate incremental improvements in technological change. These do not account for the firm's competitors, environment and sources of technology. These at varying levels are also key parts of R&D Management, Innovation Management, Management of Technology and of course Strategic Management of Technology. Small firms, it is argued, often lack managers with the relevant skills to undertake the formal process of strategic management of technology. Therefore the way networks develop over time may be affected by understanding of the key tools available in strategic decision making. Management must be able to function at a number of levels including:

- planning (forecasting; establishing objectives; setting goals; developing policies)
- organising (organisational design; job descriptions; job specifications; span of control; co-ordination; job design and analysis)
- motivating (leadership; communication; work groups; delegation of authority; employee morale)
- staffing (hiring; firing; training; equal opportunities; union relations; career development; grievance procedures)
- controlling (quality; financial; sales; inventory; expense; rewards; and sanctions)

4.4 INTEGRATING THE FRAMEWORKS

The previous section outlined the Dodgson and Rothwell (1991) factors in relation to other concepts and tools that impact on the ability for organisations to strategically manage technology at the organisational level. Each factor is broken down into its constituent elements and in doing so identifies the key areas that are of value in the strategic management of technology. Each factor identifies the value of inter and intra organisational networking (Table 4.5 summarise the network orientations identified in section 4.3). I shall show in the following sub sections each factor is underpinned by particular network variables that strongly relate to those identified in the Conway (1997) network framework.

Factors	Network Orientation
Accumulated Technological Competencies	External
Internal Strategic Cohesion	Internal
Organisational Specialism	Internal limited external
External Orientation	External
Management Skills	Internal and External

Table 4.5: The Five Factors and Network Orientation

4.4.1 Accumulated Technological Competencies Variables

The discussion in section 4.3.1 highlights the importance and impact networking has on the ability of an organisation to accumulate and utilise competencies. The accumulated technological competencies relate to the access of knowledge in order to increase internal competencies both at the group and individual level. Important is the type of knowledge (Prahalad, 1993) and what it provides the firm in terms of competitive advantage. The factor developed by Dodgson and Rothwell (1991) requires the competency to either effect existing technologies within the organisation or bring in new technological knowledge to provide certain benefits. As Prahalad and Hamel (1990) state a core competence should provide potential access to a wide variety of markets, should be difficult for competitors to imitate and should make a significant contribution to the perceived customer benefits of the end product. Also stated is the importance of how and where competencies are acquired. Therefore, to understand the development of competencies from a network perspective and to be able to map such a development requires the network variables to match those factors that aid in the development of competencies. Competencies that are already obtained by the organisation or an individual in terms of analysis require an understanding of what the competency is where it came from, how it was obtained and the way in which it is used. Also competencies may be accumulated during the study and again the type of competence is important, what it is, where it is from and how it is being utilised. Hence the variables from a network perspective start to become clear. The variables that are relevant and connect with the factor are: actor type; origin/type of relationship; transaction content type; exchange value and how it is or may be utilised. Openness will also be important in the examination and the development of competencies from area to area within the organisation. The more open individuals are to learning and knowledge the greater the chance that competencies will be accumulated and be of value across the organisation (Conway, 1997).

Actor Variables	Relationship Variables	Transaction Content Variables	Other
Individual/Group	Origin	Transaction Content Types	Openness
	Type	Exchange Value and Utility	

Table 4.6: Network Variables Linked To Accumulated Technological Competencies

4.4.2 Internal Strategic Cohesion Variables

Internal strategic cohesion is concerned with formulating strategies and communicating in the most effective and efficient ways. Hakansson (1987) in his work on innovation and technological development identifies the exchange among different agents as the product of a network. In doing so Hakansson (1987) emphasises the importance of cohesion to the network and classifies 'determinant forces'. These determinant forces or what I call 'variables' include: a functional interdependence among agents; activities and resources; a structure of power which is the systematically developed capacity to manage the different components of the network; a structure of knowledge represented by the experience and knowledge wealth previously acquired by the different agents; a temporary structure defined in terms of historical development of the network. Therefore, internal strategic cohesion is an organisation factor but as the discussion has shown it is the interaction between actors on an individual basis that leads to a high level of internal strategic cohesion.

The communication paths and number of multiple actor links leading to the strategic decision makers from the innovation network are of value to the analysis. The role of the individuals and how they link to top policy/decision makers is a major part of strategic internal cohesion. Also the direction of links identifies whether communications from departments are being shared or if there's a bias towards a particular departments or individuals. Examining the communication paths provides a map of the network's shape. If there is a high level of strategic cohesion we would expect the shape to be orientated around the centre of the organisation. A diverse flow of information from actors within the network would support a high strategic cohesion.

Actor Variables	Relationship Variables	Transaction Content Variables	Others
Individual	Reciprocity	Role	Diversity
	Multiplexity	Types	Shape

Table 4.7: Network Variables Linked To Internal Strategic Cohesion

4.4.3 Organisational Specialisms Variables

A key element in this factor is the creation of organisational flexibility. Organisational architecture, the physical environment and the way it is designed to encourage communication; climate, openness and support for innovation; and systems, methods for consultation and direction of effort are important elements of the factor. Therefore the analysis of the organisation's structure is important in regard to mechanistic/organic tendencies (Burns and Stalker, 1961); the intensity of the linkages; and how the strategic innovation network examined is placed into that structure. Understanding roles and skills developed at different levels in the organisation and examining this in relation to current structure and markets will suggest a high or low specialism. How the company develops its corporate strategy and its business units will aid the identification of the areas in which the organisation believes it is specialised. The networks identified are most likely to succeed if they fit the organisation's strategy. Where the new developments are far removed from the current technologies and products the organisation produces and develops can produce conflicts but more importantly organisational specialisms may need to be added to and developed. The diversity of actors as well as department involved in the network or surrounding the network indicates the range of specialisms within the organisation. External diversity is likely to suggest that specialisms are missing within the organisation depending on transaction content role. In identifying the links the shape of the network can be mapped allowing the identification of structure and hence suggesting whether the network and organisation is mechanistic or organic in form.

Actor Variables	Relationship Variables	Transaction Content Variables	Other
Organisation/ Innovation Network	**Formalisation**	**Role**	**Shape**
	Intensity		**Diversity**

Table 4.8: Network Variables Linked To Organisational Specialisms

4.4.4 External Orientation Variables

In section 4.3 I identified the types of external links that organisations, actors and groups have relationships with. The revised framework must be able to identify and examine those key external links. Firms can formalise a role to examine technologies externally and forecast the future but often it is individual actors, who attend conferences, who are likely to be the original contact with external individuals representing other organisations. This means identifying the actors within the network that have external links or that play the role of a boundary spanner or gatekeeper. Mapping the external links identifies the strength of the external orientation and the value of the network from the point of view of gaining competitive advantage and access to technology. Knowledge and role of customers and suppliers will be of value to understanding the external orientation and the type of link i.e. contractual, formal, informal.

Actor Variables	Relationship Variables	Transaction Content Variables	Other
Individual	Origin	Type	Diversity of external actors
	Multiplexity	Role	
	Formalised		

Table 4.9: Network Variables Linked To External Orientation

4.4.5 Management Skills Variables

As discussed in section 4.3 managers have different skills and abilities that provide benefit to the management of networks and the innovation process. The combination of these factors will provide information on the diversity of the network and may highlight where management is strong and weak in relation to the network. Managers have a number of different relationship types to contend with in terms of the differing roles within the network and differing skills. It is also important for management to manage the boundaries of a project team or network. Effective boundary management places special demands on the team leader. Boundary management strategies may be employed at the stage of putting together a team or network (Ancona and Caldwell, 1997). This will affect the selection of certain individuals especially when external orientation is key to the marketing of a product or process. The main roles of the boundary spanner (Tushman and Scanlan, 1981) are as an ambassador, as a task co-ordinator and a scout. The ambassador represents the team and prevents outsiders over loading the team with information. The task co-ordinator co-ordinates the teams efforts with others, meetings to discuss design problems, feeds back and negotiates. The scout scans for ideas, information about the market, competition and or technologies new and old. The collection of data is important. Hence, the relationship type is an important variable to examine along with the multiplexity of relations. The most important area here for examination in relation to the SMOT processes is the transaction types and the value expected and gained in order that management can use the exchange to develop policies and strategies to benefit the business and the company.

Actor Variables	Relationship Variables	Transaction Content Variables
Individual Managers	Relationship Type	Transaction Types
	Multiplexity	Role
	Formalisation	Exchange Value

Table 4.10: Network Variables Linked To Management Skills

Integrating Dodgson and Rothwell's (1991) framework with Conway's (1997) network template provides a detailed analytical tool for studying the innovation process. Tables 4.6-4.10 summarise the required variables to examine a network based around an innovation from a strategic management perspective. Table 4.11 summarises the complete set of variables identified. It should be noted that the variables taken from the Dodgson and Rothwell (1991) framework were originally based around the R&D function. This is not however a problem as an R&D group or function can be viewed in terms of Conway's (1997) framework as an innovation action-set.

Variables Categories	Actor Types	Relationships	Transaction Contents	Other Variables
Sub-variables	**External** **- Bodies** **- Firms** **Internal** **- Functions** **Management**	**Formalisation** (extent of formal recognition at strategic level) **Intensity** (strength and frequency of interaction and flow of transaction content) **Internal/External** **Reciprocity** (balance and flow over time of transaction content internal to the organisation. unilateral or bilateral through Joint Ventures Licensing Communication flows Collaboration)	**Transaction Types -** **Competencies** **Technology** **Information** **Knowledge** **Strategic Information** **Exchange Value or Utility**	**Size** - number of actors in the network **Firm Size** - relative size may affect communication **Integration (Diversity)** - of different actor types and linkages **Centrality** - degree to which the relations are guided by the formal hierarchy **Openness** - small firms more likely to benefit from effective flows of information and communication than larger firms. **Support** - climate in the organisation for innovation. **Architecture** - spread and balance of linkages. Also examined in terms of the organisational architecture. **Skills** - involved and utilised by management.

Table 4.11: Dodgson and Rothwell (1991) Framework Variables

The variables described in Table 4.11 show significant differences in the SMOT variables over the network variables set out in Table 4.1. The network framework, which as a way of examining focal innovation action sets is ideal, falls short in the area of internal examinations of organisational actor types. The two factors where development is identified and required is the organisational specialism and internal strategic cohesion factors. What this section has shown is that the network variables of multiplexity and reciprocity can be utilised to examine these factors from a network perspective. In doing this the Conway (1997) framework and mapping template will need development.

4.5 MAPPING THE STRATEGIC MANAGEMENT OF TECHNOLOGY

With the integration of the factors and variables discussed there is now a need to map the complete network as well as providing a means of examining the SMOT factors. As discussed earlier, Conway (1997) developed a template which provides a detailed way of examining and illustrating a network or networks. The template segments relate strongly to key areas within the Dodgson and Rothwell (1991) framework. Table 4.12 shows the elements of the Dodgson and Rothwell (1991) framework that relate to segments in the Conway (1997) framework.

Dodgson and Rothwell (1991) Elements	Conway (1997) Positions
Accumulated Technological Competencies	Knowledge/Suppliers/Customers
Internal Strategic Cohesion	This is shown by the links between the centre of the template to the segments. Also the links the internal network has with the Board and Strategic Decision Makers
Organisational Specialisms	Link to the ellipse
External Orientation	Knowledge/Suppliers/Customers/Regulatory/ Competitors
Management Skills	Link to the ellipse

Table 4.12: The SMOT Factors and their Network Template Links

The weakness of the template from the point of view of integrating it with the Dodgson and Rothwell (1991) framework is the undeveloped central ellipse. This represents the company but as a tool to examine networks inside the organisation it currently requires each actor to have his or her own specific template. The Conway (1997) template was designed to analyse the networks at the dyad level; provide an overall understanding of the set of actors; and show the way in which sets of actors are embedded in their environment. The ellipse must be expanded to provide a means of integrating the Dodgson and Rothwell (1991) factors that have no obvious network element in the Conway (1997) framework. The current Conway (1997) framework fails to provide the full picture of the internal sets of relationships or as Mody (1990: 4) put it 'the complete set of relationships'.

For the purposes of mapping, examining and understanding the organisation in terms of structure and common linkages between departments and actors the organisation will be broken down into departments/functions. Segments relating to functions or departments represent the internal segments. Now as highlighted in the organisational theory literature (Lorsch and Lawrence, 1970; Burns and Stalker, 1961) the contingency theory of organisation suggests that there is no one best way to organise. Therefore the appropriate internal states and processes of an organisation in the electronics industry are unlikely to be appropriate in the manufacturing of textiles given their differing external requirements. Hence the internal segmentation in the case of this template is not fixed as it is likely to differ certainly across different industries and even possibly between organisations operating in the same industry. Therefore, Figure 4.3 shows the template incorporating the common internal elements of the organisation (see Daft, 1992) whilst retaining the original Conway (1997) framework.

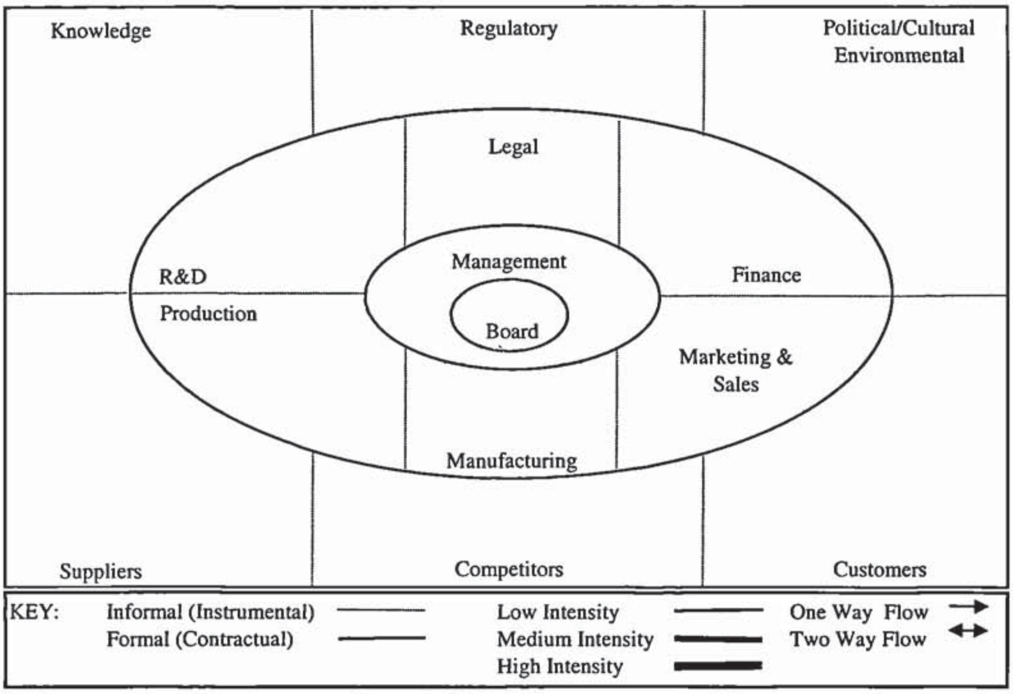


Figure 4.3: The SIN Template

It provides a stronger network detail and graphical representation of: the internal relationship; internal to external relationship and, therefore, within the innovation network an overall relationship representation. The central segments represent the internal organisation of the firm and are positioned in relation to the external segments (see Daft, 1992: 81). Graphically the framework shows the functions: which the actors are attached to; maps the internal links; and analyse the networks strategic links. Therefore the template can be used to examine the strategic management of technology in organisations from a network perspective. I am therefore defining the total network as the organisation and the partial network as the network of actors both internal and external that formally and at times informally impact on the network surrounding the innovation being studied. The partial network will be the main concern for the research in terms of understanding the innovation process and how the network changes over time.

The map must offer as much information as possible regarding the network and the relationships between internal actors and external actors. Information such as the type of relationship i.e. is it a formal relationship involving some contractual agreement or is it informal at present. How intense the relationships between actors are is relative and must be placed in the context of the situation being examined. The direction of the information flows will be one way from the teacher to the learner. However, it could be two way if two or more actors are working on similar areas with different objectives or where an alliance is formed to meet the same objectives. As stated in Chapter 2, Conway's (1997) framework does not utilise colour to provide greater distinction between transaction links. So as part of the template I wish to provide colour conventions As identified in Chapter 2, content types may include affect (the exchange of friendship); power (the exchange of power and influence); information (exchange of ideas, information and know-how); goods (exchange of money, technology or services). A colour code can be attached to these contents such that the lines (see Table 4.13) may look like the following (these could well be replaced with coding conventions such as for power $\overset{P}{\text{——}}$):

Content Types	Sub Categories	Line Colour
Affect	Friendship	Light Blue
Power	Power Influence	Dark Red Dark Blue
Information	Ideas Information Knowledge	Light Grey Red Blue
Goods	Money Base Technology Key Technology Pacing Technology Services Supplies Prototype	Yellow Black Dark Grey Mid Grey Green Dark Yellow Dark Green

Table 4.13: Content Types and Line Colours

4.6 CONCLUSION

By integrating variables from two frameworks I have produced a revised template based on Conway's (1997) original work that allows researchers to examine a total or partial network in relation to a particular innovation. The key area of revision is in the central ellipse of the Conway (1997) template. The examination of the variables from the Dodgson and Rothwell (1991) framework showed clear links between the framework and the network framework. However, this also identified definite differences and in particular gaps between the frameworks. The case in question is in relation to the examination of internal actors and functions within the organisation and placing the network in the context of the organisation. The integration and the development of the internal ellipse means the analysis moves away from the organisational view of networks to a view examining individual actors within partial as well as total networks. By developing the template in order to map partial internal networks based on individual actors within a focal innovation action-set and linking network variables to the Dodgson and Rothwell (1991) factors allows the strategic management of technology and technology strategy to be examined on the basis of technology and networking. The framework I believe provides a means of examining the dynamic relationship between technology, strategy and networking. The template will also prove invaluable in examining the innovation process over time (longitudinal) and show the dynamic evolution of a innovation network and answers questions as to why and how this occurs.

Chapter 5:
RESEARCH METHODOLOGY

CHAPTER 5

RESEARCH METHODOLOGY

5.0 INTRODUCTION

This chapter identifies the research approach including details on the literature search, the question and propositions generated, research design, methods, obtaining data and finally the strategy utilised to examine the propositions and answer the research questions. A key element to deciding on the research process is the identification of the research questions and propositions. Bryman (1989) and Yin (1994) identify a number of ways by which research can be carried out given the research question or hypothesis. I identify the research process (Bryman, 1989; Stone, 1978) to structure the methodology and this framework will direct the structure of the chapter. The research approach has a positivistic element as it involves the study of people which commends the application of a scientific method (Bryman, 1989). The strategy taken to gather information and knowledge is qualitative. The aim is to provide a breadth of information and knowledge to ensure data that relates to the individual interviewee's informal and formal social environment.

Empirical research requires that the researcher first recognise a problem or raises questions that may be addressed by some form of study. The study can be developed and ultimately analysed and tested on the basis of this question or questions. A study design is then developed to assess the hypotheses, questions or propositions in terms of validity. It should be noted that the study design and tests should be developed irrespective of whether the findings sustain the hypotheses or not (Bryman, 1989). The researcher should be in a position to implement the design or strategy and observe the values of relevant variables identified. The data that results from the strategy can then be analysed to determine whether or not they provide support for the researchers original questions and hypotheses. Finally, the researcher can then examine the results and develop conclusions in regard to the relationships found (Figure 5.1).

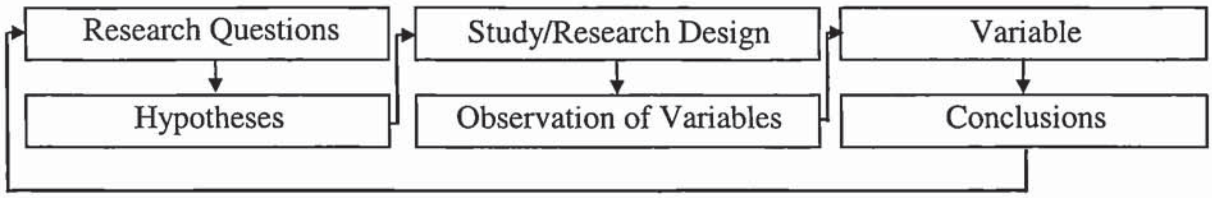


Figure 5.1: Research Process (Stone, 1978)

Empirical research tends to begin with a research question. In the case of this thesis the key question came from research undertaken by Jones and Beckinsale (1994). This research attempted to understand the processes by which mature firms become more innovative. The starting point for this study was a question about a particular aspect of organisational functioning. This issue guided the initial literature survey and in doing so informed the development of further research questions.

5.1 RESEARCH PROPOSITIONS

Chapters 2, 3 led to an identification of gaps and limitations of the SMOT literature in terms of its network perspective. This literature examination was based on an initial research question (section 5.1.1) and led to the development of an integrated framework (Chapter 4) to address many of these limitations (Chapter 4). As Stone's (1978) - research process indicates the next step is to develop hypotheses or what I shall call propositions. These propositions will assist the examination of the research questions, identifying key issues from the literature surrounding each research question and further the understanding of the innovation process. By combining the network perspective with the SMOT literature the propositions should guide the research analysis allowing the researcher to examine the relationship between strategy and network structure in traditional SMEs and mid-corporate firms.

5.1.1 Research Question and Objectives

The initial research question was '*To what extent do networks contribute to the strategic management of technology in mature mid-corporate firms?*' In order to answer this question I began with a review of particular areas of literature to understand and define the research boundaries. The key aim being to develop particular propositions to further the understanding of networks and innovation in relation to the strategic management of technology. The literature survey was also intended:

- To identify theories related to general area of the strategic management of technology.
- To identify limitations of the SMOT literature
- To identify network perspectives in the SMOT literature
- To understand the network literature
- To identify network use, value, how they develop and how they are represented in the literature.
- To identify network frameworks that aid the understanding of SMOT.
- To examine whether a particular SMOT framework could be integrated with a network perspective.

This survey provided a general understanding of the SMOT literature. By identifying the SMOT literature limitations opportunities for research development occurred. It was the identification of a lack of network perspective identified in Chapter 2 that led to the examination of the network literature. From which I was able to focus the research objectives to a manageable and realistic level.

During the literature survey, all questions that emerged from the readings were noted. It was then possible to develop a set of objectives and questions. The objectives and questions were based on the network limitations of the SMOT literature identified in Chapter 2 (DeBresson and Amesse, 1991; Coombs et al, 1996). Chapter 2 and 3 also highlight the limited network research regarding SMEs and mid-corporate firms, the minimal number of longitudinal studies of innovation (Afuah, 1998) and as discussed in section 2.7, the potential for a framework to examine networks in relation to SMOT and in-particular strategy. The question that arises for the thesis is whether network theory can be better integrated into the strategic management of technology theory.

In Chapter 2 I identified the current work in the field of networking that relates to technology, innovation and specifically the strategic management of these. The examination of the literature raises a number of questions that were identified at the end of Chapter 2. From these I believe four key questions can be examined and answered through meeting the following thesis objectives:

Objective 1: To integrate two theoretical perspectives and develop a unified analytical framework. Coombs et al (1996: 35) identified the lack of uniformity in the examination of networks and strategic management. Therefore a key objective is to develop a framework that unifies key variables and theoretical understandings. This will increase the understanding of the innovation process from the perspectives of networking and SMOT (to be carried out from a singular disciplinary framework). This combined framework strengthens the understanding of relationships between the perspectives and the dynamics between the two.

Objective 2: To examine the innovation and strategic management process from a network perspective. One of the objectives of the thesis is to utilise the combined framework (Chapter 4) to examine the process within organisations. These organisations are SMEs/mid-corporate firms in traditional sectors rather than high-tech organisations that have in recent years tended to be the focus of research on smaller firms. This may provide a new insight into firms that according to the literature (Jones and Beckinsale, 1994) have difficulties in developing their innovative capacity.

Objective 3: To examine the linkage between network types and corporate/technology strategy. Given the way in which the framework was developed and by utilising a well-defined research strategy the research should allow the relationship between strategy and networks around the innovation process to be analysed at particular levels. These will include the individual actor level, the strategic level and the organisational level in terms of impact. In examining these linkages and relationships the potential is for the innovation process to be mapped and analysed from a dynamic perspective (Afuah, 1998).

5.1.2 Key Research Questions and Propostions

The objectives were developed from the analysis of the literature (Chapters 2 and 3) and the weaknesses and limitations identified. At the end of Chapters 2 and 3 general questions were raised and it is these that inform the key research questions. These key questions provide the basis for a set of propositions that may be researched and examined utilising the developed framework. The propositions will be used to set the structure for the case study analysis and the overall analysis of the research.

Firstly, Chandler (1962: 13) states that *'structure follows strategy and that the most complex type of structure is the result of the concatenation of several basic strategies'* This suggests that the strategy being followed by an organisation is best achieved through a particular structure. The SIN framework in Chapter 4 allows this proposition to be examined and raises the question

Question 1: Does corporate/technology strategy impact on networks both at the development of a network stage as well as during their use?

Question 1 asks whether strategy affects the networks that are utilised by mid-corporate firms to achieve innovation and competitive advantage. Work by Chandler (1962) suggests that the answer should be positive. The conclusion from his research states that a firm must adjust its organisational structure in accordance with the objectives it seeks to achieve: *'...different organisational forms result from different types of growth'* (Chandler, 1962: 13). Where growth is assumed to represent strategy and the organisation a structure. Chandler's (1962) work also suggests that not only organisational structure is affected - *'new strategy may add new types of personnel and facilities.....it can have a profound effect on the form of its organisation'* where resources are viewed as *'financial capital; physical equipment: sources of raw materials, research and engineering laboratories; and, most important of all, the technical, marketing and administrative skills of its personnel'* (Chandler, 1962: 14). Therefore, the actors and relationships will be affected by corporate/technology strategy and hence organisational structure will change which may impact on particular internal networks. Doz and Hamel (1997: 578) develop this further in relation to strategic alliances and argue that such structures have a 'key role' in strategy implementation. Therefore the propositions raised from the literature are:

- types of networks employed to achieve particular innovations follow corporate/technology strategy.
- the type of strategy (i.e. the types identified by Berry and Taggart (1998) see Chapter 2) will require particular networks to achieve the objectives.
- the type of strategy should also affect network resources and the network shape

Secondly, given the work by Chandler (1962) and Doz & Hamel (1997) and the fact that the literature fails to examine SME/mid-corporate firm alliances in relation to the specific network literature identified in Chapter 3 then I ask the following question:

Question 2: What types of networks do mid-corporate firms in traditional manufacturing sector use to aid product and process development through access to new technologies?

The literature relating to product and process innovations has tended to be dealt with in a limited manner. Often such innovations have tended to be classed as one and the same (Anderson and Tushman, 1997; Holt, 1988). However, as shown in Chapter 2 this is not actually the case. Porter (1985) suggests specific strategies for a product innovation and a process innovation. With product innovation being orientated to market needs whilst process innovation focussing on the internal value chain of the organisation. Further examination of the product and process innovation literature (Goodman and Lawless, 1994) suggests that each innovation type will require very different networks to achieve each innovation type. Individual innovation will not impact on the rest of the organisation whilst synergistic innovations will impact on other areas of the organisation. The later involves other organisational processes. We would therefore view product innovation as impacting less on the organisation than a process innovation. Therefore, Question 2 raises the following proposition:

- product innovations will require networks which have greater external orientation.
- process innovations will require greater internal orientation.
- product innovations should involve fewer internal network actors than process innovation

In Chapter 3 I present the template developed by Conway (1997) for mapping focal action sets which in Chapter 4 was utilised to develop the SIN framework. This mapping allows individual actors within the innovation network and their links to other actors to be mapped. The fact that the mapping can take a 'snapshot' of the innovation network at any time during the innovation process suggests that changes in the network can be mapped. Hence a time series approach to data gathering is potentially possible to provide a dynamic understanding of the innovation process. It also raises the question of whether within the innovation process there are significant network stages and if so what those network maps look like and what can they tell us about the innovation process and the strategic management process. Therefore two generic questions arise:

Question 3: Are there stages in the development of an innovation network?

Question 4: If there are identifiable stages how do they develop and what influences them?

Question 3 is related to the stages of the innovation process. Both Rothwell (1994: 40) in his examination of the linear model of innovation and Afuah (1998) in his examination of innovation dynamics considers stages within the innovation process. In identifying that various individuals and groups will play differing roles during the development of an innovation the question arises: does each stage involve different networks? The research relating to innovations has tended to be rather static in its view of the innovation process (Afuah, 1998). I believe that given the network literature (Freeman, 1991; Olivers and Ebers, 1998) identifies many network types which aim to achieve specific objectives then we should expect the utilisation of these network types at different periods during the innovation process. A dynamic innovation process will utilise different networks to achieve particular innovations and strategies. As the innovation process develops various actors and therefore networks will be accessed. This leads to the following propositions:

- the networks evolve throughout the innovation process.
- each network stage will utilise network types.

The final question raised issues associated with influences on the stages of the innovation process. If the propositions for question 1 are confirmed then strategy will have an influence on the stages. However, the framework used to undertake the case study analysis also examines management skills, internal strategic cohesion, accumulated technological competencies, organisational specialisms and external orientation. In analysing and examining the factors I would expect to see identifiable influences within each case study.

- where competencies and skills are lacking then externally orientated networks may be utilised

- where internal strategic cohesion is valued then communication between divisions and functions as well as with senior managers will be shown by the SIN framework - the greater the internal strategic cohesion the greater the actors internal links and flows
- management skills are likely to influence the network shape and the actors chosen for the innovation process
- the types of external links are likely to be influenced by strategy e.g. to develop future technology then a mid-corporate firm would be best placed to utilise and orientate actors towards the knowledge segment of the SIN framework
- the relationship between the development and strategy may affect the embeddedness of the network within the organisation.

The research is based around the key research question and the four sets of propositions discussed in this section. The propositions will direct the study and research design in terms of the approach taken. This next stage is possibly the most important element of the research process and informs and directs the strategy.

5.2 STUDY/RESEARCH DESIGN

The research design is the plan that guides the investigator or researcher in the process of collecting, analysing, and interpreting observations and data. It is the logic that links the data to the initial study questions. It is a logical model that allows the researcher to draw inferences concerning causal relations among the variable(s) under investigation (Yin, 1994). The research design also defines the domain of generalisability, which is whether the interpretation can be generalised to a larger population or to different situations (Nachmias & Nachmias, 1992). Five components are seen to be critical in the research design are:

- the study question
- the questions propositions
- the unit(s) of analysis
- the logic linking the data to the proposition
- the criteria for interpreting the findings

The study question directs the research strategy to be used. The second component directs attention to something that should be examined within the scope of the study. The unit of analysis is fundamental in that it defines the study focus and is in general related to the research question. The final two criteria represent the data analysis steps in the research and the research design should lay the foundations for this analysis.

5.2.1 Research Methods

The choice of research methods is broad and includes: experiment; survey; archival analysis; history; and case studies. Such methods are also known as strategies (Yin, 1994) or designs (Bryman, 1989) and are chosen depending on the type of research questions. Yin (1994) points out that research questions can take the form of How?, Why?, Who?, What?, Where?, How many?, How much? He also points out that such questions may or may not require control over behavioural events and focus on contemporary events.

Strategy	Research Question	Requires Control over Behavioural Events?	Focuses on Contemporary Events?
experiment	**how, why**	**yes**	**yes**
survey	**who, what, where, how many, how much**	**no**	**yes**
archival	**who, what, where, how many, how much**	**no**	**yes/no**
history	**how, why**	**no**	**no**
case study	**how, why**	**no**	**yes**

Table 5.1: Relevant Situations for Different Research Strategies (Yin, 1994)

Research can be categorised as either qualitative or quantitative. Qualitative approaches emphasises individuals interpretations of their environments and of their own and others' behaviour (Burgelman, 1985). Qualitative research relies on what people say and the context in which their actions take place. Priority is given to the perspectives of those being studied. Researchers often become insiders and spend time interviewing, talking and observing individuals, groups and the organisation generally to build a picture of how those under study interpret their world and situations. Qualitative research tends to focus on unfolding events over time (Bryman, 1989) with face to face contact with subjects. Quantitative research tends to give little attention to the context - researchers are likely to take a number of variables which represent a sample of organisations and therefore rarely get a feel for how these variable fit with other aspects of their functioning (Bryman, 1989). Quantitative research entails mainly a static analysis in which relationships among variables are explored. Qualitative research can be loosely structured where as quantitative research tends to employ a rigorous preparation of a framework within which data are to be collected. It should also be noted that quantitative research more often than not involves limited contact between most actors involved in the study. The use of questionnaires rather than interviews and observations is the most usual form of contact. The two approaches to research discussed may involve particular strategies. A qualitative approach would include case studies and historical where as a quantitative approach could utilise experimental, archival data and surveys.

Strategy	Method	Advantages	Disadvantages
Experiment	Laboratory, Field	Provide a method to make strong claims about causality.	Experimenting with people can lead to changes in normal behaviour.
Survey	Interviews or Questionnaires	Provides a means to examine patterns of variables by way of sampling.	Potential for sampling bias.
Archival	Pre-existing material - records, memos, speeches and more....	Data is documented at time of events being studied. The potential for human bias is also removed given the documents where not expected to be used for research purposes.	The way in which data was recorded however can be difficult to check and therefore bias can enter the research. Also making comparisons over time can prove difficult given changes over time.
History	Data is based on historical records	Data provides an insight into the past	Valuable data can be limited or difficult to identify given nature of data. Data less likely to be documented at the time.
Case Study	Interviews normally but questionnaires are possible with organisations, groups or individuals.	Very detailed Longitudinal studies possible.	Can be time consuming and are often biased by the interviewees perception of the details under discussion. Least developed analytical tools

Table 5.2: Research Strategies Summarised

As seen in Table 5.1, who, what and where questions support survey strategies or the analysis or archival records. Such strategies are advantageous when the research goal is to describe the incidence or prevalence of a phenomenon or when it is to be predictive about certain outcomes (Yin, 1994). The other choice of question, how and why, lends itself to explanations and is likely to lead to the use of experiments, histories or case studies. Such questions give rise to these strategies because they deal with operational links needing to be traced over time. Unfortunately for any researcher choosing their research strategy it is not always as simple as the table suggests. Yin (1994) states that there are often large areas of overlap among strategies so that some questions will clearly give rise to the possibility of using more than one strategy. Table 5.2 (details from Bryman, 1989 and Yin, 1994) summarises the strategies that might be used depending on the questions being asked.

	Experiment	Survey	Archival/History	Case Study
The Question	The strength of experiments is that they allow the researcher to make strong claims about causality and that one thing has an effect on another......and is often perceived as a model research design (Bryman, 1989).	The survey or social survey is a framework through which data can be collected. The objective is then to examine patterns of relationships between variables.	The question being asked may require a particular source of data especially if it is not contemporary/ present data.	Case study questions tend to relate to the examination of contemporary events.
The Environment	A controlled environment is vital in experiments which can prove more difficult when the experiment is not observed on some inert object.	Such a strategy attempts to sample or represent the total population.	Such a strategy would be advantageous in relation to issues and relationships, changes ect that have occurred. The environment will be the organisation or group but during a previous period of time.	A particular group or organisation or possible a small number of organisations with a particular relationship.
Bias	Experiments can impact or alter human behaviour because people know they are the object of the experiment (Bryman, 1989).	Sampling bias is possible especially where certain units are over represented. Techniques can be used to aid removal of bias such as random sampling or multi-stage cluster sampling.	Bias is often removed as the sources are and were never aware that the data would be used in a study. However, differences in the way in which recording data was recorded can easily be a source of bias within and between firms, as well as over time. (Bryman, 1989).	The emphasis is often on individuals or organisations interpretation of their environments and of their own and others' behaviour. The understanding is often angled on the organisation from the participants own terms rather than the researchers.
Researchers Involvement	Experiments are likely to see the researcher intervene in order to observe what was effected by the intervention.	Researcher does not intervene in the organisation. Statistical analysis is a key part of the researchers role.	No involvement within the organisation or in terms of intervention.	No intervention but more often than not are qualitative and utilise interview techniques.

Table 5.3: Summary of Individual Strategies (Yin, 1994).

Each strategy has its advantages and disadvantages depending on: the questions being asked or the hypothesis being tested; the environment being studied; the potential for bias; and the researcher's involvement. Table 5.3 summarises the positive and negative attributes of the individual strategies.

5.3 OBTAINING DATA

As is clear from the previous sections, researchers can employ different strategies and designs depending on the questions to be answered and the subjects to be researched. Data can be obtained in a number of ways: reports, company journals, news reports or more directly through interviews and questionnaires. The type of data gathering approach depends on the approach - qualitative or quantitative. The same data may be available in both cases however what tends to vary is the way in which this data is accessed, organised and analysed. Archival will likely use news reports and company reports; surveys will likely use questionnaires or case studies may use interviews.

Interviews provide a number of means to obtaining data types dependent on the interviewers/researchers requirements. The interview process allows the interviewer to ask questions that may vary to the degree of structure both in the question and in the expected response. These are in the literature identified as structured and unstructured categories (Kumar, 1996). A typology of interview categories is identified in Table 5.4.

		Interview	Items
		Unstructured	**Structured**
Response Possibilities	**Unstructured**	Unstructured Interview	Semi-Structured Interview - I
	Structured	Semi-Structured Interview - II	Structured Interview

Table 5.4: Typology of Interview Categories (Stone, 1978)

Questionnaires have a narrow focus as the responses tend to be fixed, which limits the total information gathered and the detail per case may well not be answered by the most appropriate person, and the same response by different individuals may not mean the same thing. Often researchers employ a form of what is known as a 5-point Likert and Likert (1976) scale in which the respondent is asked to select one of the following: (1) strongly agree, (2) moderately agree, (3) neutral, (4) moderately disagree, & (5) strongly disagree. Structured interviews are based on a collection of specific and precisely formulated questions which are asked of a respondent by an interviewer (Bryman, 1989) and provide a far richer source of information than questionnaires. Structured interviews are one approach to data gathering (Bryman, 1989). Structured interviews require each respondent to be provided with the same set of questions, in advance of the interviews. Standardising the questioning means that variations in the responses can be attributed to genuine variations and not to divergence in the type or order of questions. Of course, an interview is not without its problems and difficulties as they are time consuming and difficult to set up.

5.4 CHOSEN STRATEGY

The proposition on which the study/research is based contains the questions how? and why? This directs the research strategy towards experiment, history or case studies (Yin, 1994). Histories are the preferred strategy when there is virtually no access or control. The contribution of historical data capture is in dealing with the 'dead' past (Yin, 1994). Histories can be done on contemporary events but then this tends to lead the strategy in the direction of case studies. Experiments are interesting but require the researcher to place constraints or control over the study variables. This is very difficult when you research organisations and individuals within those organisations that are potential innovators and are already time and cost constrained. This leaves the case study approach that deals with contemporary situations and does not imply any control over the behaviour of variables or subjects to be studied.

5.4.1 Case Studies

Case Studies: entail the detailed examination of one or a small number of 'cases' (Bryman, 1989) The unit of the analysis is often the organisation or a social phenomenon (Kumar, 1996) within departments or groups. Such an approach is often seen as a qualitative approach as the emphasis is often on individuals or organisations interpretation of their environments and of their own and others' behaviour. The understanding is often based on the organisation from the participant's own terms rather than the researchers.

Most qualitative research takes the form of case studies. However, not all case studies can adequately be described as instances of qualitative research methods. Two key elements of case study research are the use of interviews and observation to capture data on a particular case. Interviews are meetings in which the interviewer directs questions at the interviewee and then records the obtained responses (Stone, 1978). Meetings involve face to face contact and interaction between two or more parties. The telephone is also another way of conducting an interview if distance, time are a problem. Interviewers read out questions to the interviewee and then records the response. A questionnaire may or may not be anonymous and will generally not involve interaction between respondent and interviewee.

Case studies have their critics (Rosenthal, 1966; Sudman & Bradburn, 1982) especially with regards bias and the difficulty of generalising the findings given the small number of cases involved in the majority of studies. Yin (1994) makes it clear that any case study researcher should work hard to report all guidance fairly and that bias be removed. Another common concern is that case studies provide little basis for scientific generalisation. Yin (1994) points out that generalisations are possible. It is clear that through a single case as with a single scientific experiment generalisation would be unlikely. However, using multiple case studies as with multiple sets of experiments, which replicate the same phenomenon under different conditions means generalisation, is possible. *'a conscious attempt to increase the number and range of types of organisation investigated may mitigate this point somewhat, as in the studies by Sutton 1987 and Yin 1979'* (Bryman, 1989: 47). Again the research design is important and generalisation is appropriate to the theoretical proposition. Finally a major criticism of case studies is that they take too long, resulting in large, unreadable documents. Case studies are empirical and a form of inquiry that do not depend solely on ethnographic or participant-observer data which can take time and involve a great deal of investment in field efforts. The way in which researcher approaches the research design can aid in solving the problems outlined above.

The analysis of case studies consists of examining, categorising, tabulating, or otherwise recombining the evidence to address the initial propositions/hypothesises of the study. Case studies are however viewed as having the least developed analytical strategies. The first possibility is to follow the theoretical propositions that led to the case study. The proposition should guide the case study analysis focusing attention on certain data and to ignore other data. Secondly, where there is not a theoretical proposition but a descriptive purpose then the key is to develop a descriptive framework for organising the case study. A descriptive approach can also aid the researcher in identifying the appropriate causal links to be analysed (Yin, 1994). Many of the research strategies can adopt a longitudinal approach. Bryman (1989) attaches longitudinal design to surveys although it may be used in case study analysis as well as historical data. The longitudinal approach adds a temporal element to the research providing data either qualitative or possibly quantitative that can show changes over time and the dynamics involved in the units of analysis.

> *'If the events over time have been traced in detail and with precision, some type of time series analysis always may be possible....... the ability to trace changes over time is a major strength of case studies'* (Yin, 1994: 113).

The case study approach was chosen in order to answer how and why research questions. The how and why questions are based around a contemporary set of events over which I had little or no control (see Yin, 1994). The data reported in this dissertation is based on a number of case studies in order to examine data and gain answers to the questions in equivalent situations. Given the questions to be answered and the examination of network relationships a qualitative approach would appear to give a rich set of data that would inform the network template. Therefore, to maximise the advantages of a qualitative case study, the information was gathered by structured interviews (the same questions being asked in all cases), company documents and more general literature such as company brochures. However, value was put on the interview data over and above any documentation or general literature. The reasons being that the information and data gathered is related to specific networks which are rarely documented or appear in external documents or even internal documentation. This is even more important in relation to the longitudinal approach. By following networks as they develop over time, there is unlikely to be specific documentation relating to the actors. The longitudinal approach is expected to remove the problems of historical data gathering which is often used in case study research. Following a case as it happens means that observations can be tracked in real time. Barley (1986) argues that mapping 'emergent patterns of action' demands a detailed qualitative approach stating that 'retrospective accounts and archival data are insufficient'. This should remove the possibility of missing data from individuals being interviewed because they fail to remember things that may or may not be important. This real time tracking of the data also means that as organisational changes happen, including strategy and structure, I can map the networks in relation and in the context of such changes.

5.5 CHOOSING THE CASES

Chapter 6 outlines the cases in this study which were all traditional manufacturing firms. This meant that they had to have started life as a non-subsidiary and established by an individual or a group. In all cases the firms were independent and free from outside control in taking principal decisions. Being traditional manufacturing firms there was no prerequisite for the firms to have a strong scientific or technical base except that they had to be considering examining and developing new technologies. All firms employed 500 staff or less, in fact all but one were under 250 employees. I therefore define these firms as mid-corporate rather than SME (Jones and Smith, 1997).

The research strategy was discussed in the previous section and in summary it is qualitative, case study based, longitudinal and above all detailed. A number of approaches were considered in identifying and accessing potential cases. These included: approaching firms operating in and around science parks in the Midlands; approaching firms involved in numerous technology and innovation awards; approaching previous research sites for access; and approaching MBA students who worked for mid-corporate firms. Given the in-depth approach cases had to be selected on the basis of detailed research access. A large number of companies were not ideal for this study given the longitudinal approach and the need to collect a rich source of detailed data. Too many companies could have compromised the ability to achieve this goal. Hence the approach taken was to access mid-corporate firms with which I had had previous contact or to contact Aston MBA students who were examining their firms technology and strategic management practices. Given the need to develop a relationship that would last some 18 months or more and would require a great deal of detailed data to be obtained then accessing organisations where a relationship had already been developed provided a major benefit to the type of access that could be obtained. The identified firms were considered to have a strong base for a case study approach to allow the research questions/propositions to be examined and tested. All are low-tech but had begun to utilise new technologies to improve their competitive advantage. Initial discussions were held with a range of managers. Depending on first contact then business managers, development managers and marketing managers were spoken to accertain whether they could provide access to required developments. This initial contact led to access to project leaders/managers that had the ability to provide the necessary access.

Mitchell (1969: 58) points out that studying a network should begin with one individual and map their relationships (Director or project manager) or what he terms 'first order contacts'. The network is developed from this point by identifying key links to the specific content for a specific task (Mitchell, 1969: 58-60). Therefore the actors within each firm were chosen on the basis of a particular innovation/development. The development was used to constrain the boundary of the network of actors internally and externally. The actors were identified through discussions with project leaders within each organisation. A set of direct and indirect relationships mobilised for the specific task was obtained by firstly interviewing the project manager and then the actors identified. Actors were only included for interviews if they had a formal relationship with the project (this was the same for external actors). However, informal links were also documented to identify other networks that individuals may be involved in within the organisation.

5.6 ANALYSING THE DATA

The case study approach to the research should aid in answering the 'how' and 'why' questions. However a framework was needed to assist this process. The choice was to either develop a new framework or use existing frameworks from the literature. On examination of the literature no one framework provided the elements required to answer the research questions although there were many that could answer individual research questions and assist in the analysis. It was therefore decided to develop the framework in Chapter 4. The integration of the two frameworks provides a network perspective to a framework intended to analyse the strategic management of technology. This was achieved by developing the Strategic Innovation Network (SIN) framework based on Conway's (1997) network template. The framework identifies the areas and variables that need to be examined, categorised and tabulated to ultimately test the propositions outlined.

The framework provides a means to identifying networks that relate to particular strategies during the course of various innovation projects. Also by tracking the project over the period of 18 months, although not necessarily the life of the project, the framework provides a way of tracking networks over the course of a project and during the stages of the innovation process. In doing this, I show that the innovation process goes through a number of network stages or orientations depending on strategy. The set of questions developed had to identify the variables that related to each actor. In doing so they had to be flexible enough to be asked of all actors identified. Given the longitudinal approach, the same questions were asked of each actor every three months over the course of 18 months. Because, the interviews were held every three months there was the potential to identify network changes over the 18 months period. These network stages or orientations required different actor types, transactions contents and relationship types over the period of the project. Therefore, I show a very dynamic network process underpinning the innovation process and the strategy employed.

5.7 METHODOLOGY PROBLEMS

To examine the set of propositions utilising the framework through a qualitative approach there was a choice of whether to be full time within the organisations or to research at arms length by undertaking interviews at specific periods. After, initial discussions with project leaders in each organisation it was clear that for me to spend a long period within each organisation around the project would have involved a lot of time observing the same daily activities. In many respects the projects were seen to be highly routinised. The decision was taken to undertake the research and interviews on a part time basis. Going into the organisation at a given point in time. A 3 month period was chosen on to allow time to gain access to each cases set of individuals. The period aimed to avoid missing any developments in the networks and as a back up I obtained agreement from the project leaders to use the phone at least once a month to ensure changes, developments and key issues were not missed. The thinking behind this was that even if a key development was missed that it would be fresh in the actors and project leaders minds and I would be able to still gather information and knowledge relating to the research question. If I had approached the research from a historical perspective the potential for key information to be missed or forgotten would be increased.

Another key methodological problem relates to identifying the boundary of the network. As stated in Chapter 3: 88

> *'Important to studying networks (Conway, 1997) is the attributes and/or participation of the actors themselves and the second relates to the manner or way in which the partial network is anchored i.e. around a particular actor or group of actors.'*

In examining innovation projects the partial network is anchored around a group of actors that impact formally on the project. The formal group researchers must be aware of the potential of informal links to aiding an actor's position in the project. The final issue here was how wide to cast the research net. A decision had to be made on the maximum number of actors not directly linked to the focal actor. Setting the boundaries is important and two approaches were identified in Chapter 3. Laumann (1983), developed the nominalist approach and the realist approach. The approach I have taken in the discussions with project leaders to identify the actors is the realist approach. The project leader set the boundaries of the network given the project we identified to be examined based on my criteria for selection of a network. The network selection was based on a partial network that tends to be anchored around a group of actors based on a project that have the potential for developing an innovation. Interviews were conducted every 3 months although not always to the day. Depending on the case the number of interviews varied from a minimum of 6 interviewees to over 10 at the start. Prior to each interview period the project leader was contacted to update my interview schedule where individuals had changed or were not available. Each interview lasted a minimum of an hour which meant that interviews were conducted over two or three days. Having five cases meant that ten to fifteen days could be taken up with undertaking interviews. Interviews in different organisations were spread across the month rather than cramming them in to a 2 week period. This was often based on the dates that the individuals could meet rather than my own preferred dates. During the 18 month research period this continual update was difficult to manage as precisely as I would have liked. At times contact with particular individuals was impossible due mainly to their work schedules. This was generally resolved through persistence, without being difficult and with some help from my supervisor. However, I would like to add that all organisations involved and actors interviewed gave up as much time as they could and it was appreciated. At least 150 interviews were conducted over the 18 month period.

5.8 SUMMARY

The initial research questions where used to identify a methodology that would best suit the objectives of the research. The research strategy was chosen to answer the particular research propositions developed. The strategy provides a means to answering the particular how and why questions that underpin the propositions. With the SIN framework and the case study strategy examining innovation networks allows the research to follow the network over time giving the research a longitudinal element. Such an approach is only valuable if the analytical framework supports the analysis. The framework developed in Chapter 4 guides the case study analysis focusing attention on certain data. It provided a descriptive element in order to organise the case study and although not driving the methodology the framework did guide and inform further research questions asked. In terms of generalisation and the representation of the population of case studies each case is treated in exactly the same way. The set of questions posed to each actor, across the cases, are repeated to provide the possibility of comparisons and especially to see where there are similarities and differences in the networks and in the approaches to innovation and its strategic management. This supports the longitudinal approach taken which also, in conjunction with the SIN framework, provides a dynamic perspective to the analysis and the visualisation of the innovation networks. Each actor was interviewed as many as 6 times during the 18-month research period. This varied in relation to actors who move on or join the network at a period during the research. In between the interview periods the phone was used to contact each project leader to update project information and to allow the next interview process to be organised prior to attending each case. Each project leader was key to identifying the network boundary and contacting the actors to be interviewed. External actors and bodies were not interviewed for the purposes of the research. The research concentrates on the partial network of actors (Mitchell, 1969 and Scott, 1991) inside the organisation. Therefore, the network is embedded within the organisation and its environment.

Chapter 6:
INDIVIDUAL CASE STUDY DETAILS

CHAPTER 6

INDIVIDUAL CASE STUDY DETAILS

6.0 INTRODUCTION

The following chapter provides information on each of the companies involved in the thesis. This information includes history, turnover and sales information, business, markets, products, technologies, competition, structure and innovation management. In addition, I start this chapter by examining the general sector they operate within which in the context of this thesis is the UK manufacturing industry. Each organisation is classed as a mid-corporate firm (Jones and Smith, 1997) with none of them by 1999 having over 500 employees. In fact depending on which definition you accept (i.e. Department of Trade and Industry (DTI), European Commission or OECD) the firms could all be classed as small to medium sized firms.

Each firm was chosen because of their traditional manufacturing backgrounds and attempts to increase their innovative capacities. All had begun to access new technologies in order to develop new products and processes. Their markets were not strictly hi-technology, however, each firm has tried to either develop or acquire technologies internally or externally to enhance their competitiveness.

The first two organisations discussed form the basis of the main case chapter (Chapter 7). The reason being that the development projects identified in each relate to distinct innovation types (one product the other process). The three other cases will form the basis for a second case study chapter that adds and supports the main cases study chapter. The supplementary data from the three will be used to support and possibly provide variations to the first two cases. The analysis will utilise the SIN framework (Chapter 4). As stated in Chapter 2 technology and technological innovation is viewed in the following way

> *'technology is used in the sense of a practical application of scientific or engineering knowledge. A technological innovation is then any product launched by the organisation, or any process introduced in production, for which the innovating unit had*

to familiarise itself with one or more new technologies, or with a new combination of existing technologies' (Loveridge and Pitt, 1990: 40).

However, before I outline the case study organisations the cases need putting in context from the point of view of defining SMEs and mid-corporate firms and what makes them traditional rather than high tech? The UK manufacturing sector in which they operate and the extent of innovation will be examined using DTI statistics.

6.1 SMEs AND MID-CORPORATE FIRMS

There were an estimated 3.7 million active businesses in the UK at the start of the thesis in 1996 (Figure 6.1) and this figure has not changed by 1999 according to DTI new statistics. The most significant change has been since 1951 with an increase of over 18,000 enterprises.

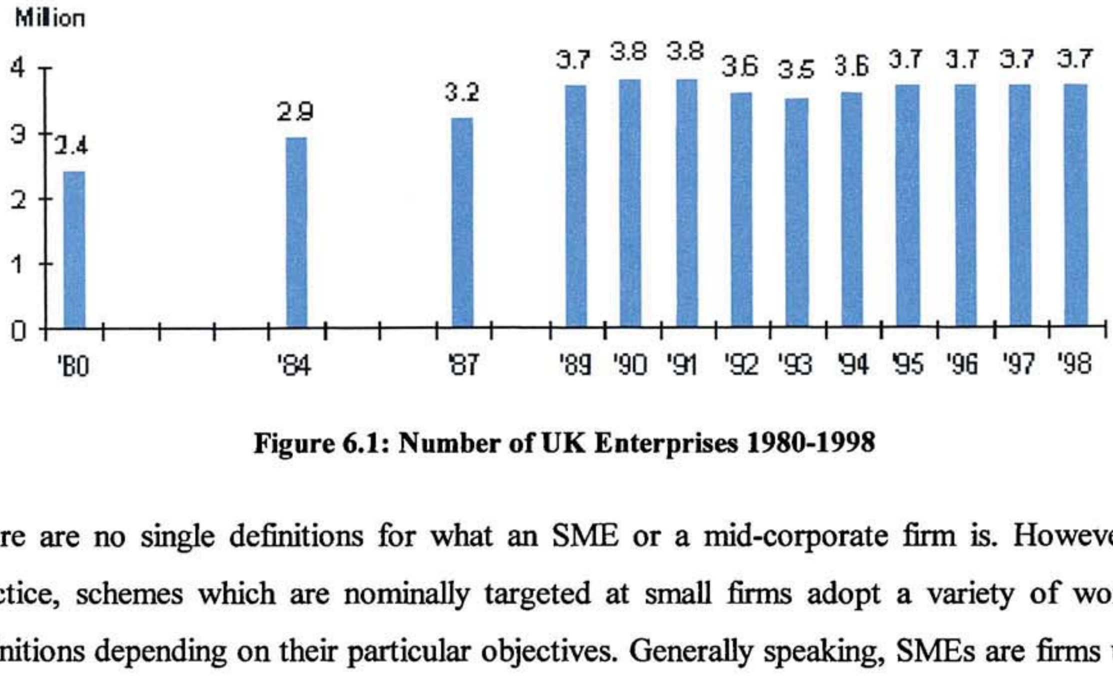


Figure 6.1: Number of UK Enterprises 1980-1998

There are no single definitions for what an SME or a mid-corporate firm is. However, in practice, schemes which are nominally targeted at small firms adopt a variety of working definitions depending on their particular objectives. Generally speaking, SMEs are firms up to 250 employees and anything over 250 employees is a large firm. Usually they can be sub devided into those which are in traditional industries, those which are modern and with a niche market and new technology companies. The lack of a single definition for a small firm, is mainly due to the wide diversity of businesses. The best description of the key characteristics of a small firm remains that used by the Bolton Committee in its 1971 Report on Small Firms. This stated that a small firm is an independent business, managed by its owner or part-owners and having a small market share. The Bolton Report also adopted a number of different statistical definitions. It recognised that size is relevant to sector - i.e. a firm of a given size could be small in relation to one sector where the market is large and there are many competitors; whereas a firm of similar proportions could be considered large in another sector with fewer players and/or generally smaller firms within it. Similarly, it recognised that it may be more appropriate to define size by the number of employees in some sectors but more appropriate to use turnover in others. Across government, it is most usual to measure size according to numbers of full-time employees or their equivalent. Section 249 of the Companies Act of 1985 states that a company is "small" if it satisfies at least two of the following criteria: turnover of not more than £2.8 million; balance sheet total of not more than £1.4 million; not more than 50 employees. A medium sized company must satisfy at least two of the following criteria: turnover of not more than £11.2 million; a balance sheet total of not more than £5.6 million; not more than 250 employees. For statistical purposes, the Department of Trade and Industry usually used the following definitions: micro firm: 0 - 9 employees; small firm: 0 - 49 employees (includes micro); medium firm: 50 - 249 employees; large firm: over 250 employees. Above I have shown that SMEs are generally taken to mean organisations that have less than 250 employees but this can exclude a large number of medium sized firms which play a similar roll in the UK economy. As Jones and Smith (1995: 2) point out the National Westminster Bank refers to such firms as the 'mid-corporate sector' which encompasses enterprises with a turnover between £1 million and £130 million.

The hallmarks of SMEs and mid-corporate firms are limited financial and human resources and economy of scale. As Lee (1994) points out SMEs differ from large organisations in a number of ways. In particular, background, competencies, aspirations and strategic objectives of entrepreneurs are much more likely to impact in an SME. Owners and managers in small firms are also less likely to have undergone formal management training. Rothwell (1983) examines many of the advantages and disadvantages of small firms in innovation and although quite general they tend to be more specific to SMEs than large firms: marketing: ability to react quickly to market changes; management: less bureaucracy. dynamic, entrepreneurial managers; internal communication: efficient and tends to be informal. Can provide quick response to problem solving; qualified technical manpower: often lack suitably qualified technical specialists; external communications: often lack the time and resources to identify external resources and scientific and technological expertise; finance: capital can be a problem. Very little risk capital available; economies of scale: can form substantial barriers to market entry and success where economies exist; growth: rapid growth unlikely due to lack of capital. Entrepreneurs may find a increasingly complex organisation difficult to manage;

patents: costs in patent litigation hard to meet; and government: unit costs for compliance to complex regulations difficult to cope and manage.

Dodgson (1993) points out that for an SME to be successful in innovation tends to require 'a whole range of information inputs'. He also states that there is far more to innovation for an SME than 'straightforward transfer of technology or a formal joint venture agreement'.

- Traditional SMEs are generally reluctant to take key staff out of the day-to-day operations and to harness opportunities provided by technological progress. They have limited risk-taking capability.
- New technology based firms tend to provide and develop opportunities for entrepreneurial specialists to set up business. They are greater risk takers and usually employ a small number of staff in the 0-9 workers category.

6.2 MANUFACTURING PATTERNS

At the start of 1996, at least 99% of businesses in all but one industry sector were SMEs. In the exception, the electricity, gas and water supply sector, only 85.7% of businesses were SMEs, a decline from 90.0% in 1995. There were large variations by industry sector in the share of employment. Most sectors saw a decline in the share of employment in SMEs, although the other community, social and personal services sector saw a 1.7 percentage point increase on 1995 (DTI website).

The share of employment in small businesses was higher than average in agriculture, forestry and fishing and in most service industries at the start of 1996. Small businesses continued to dominate employment in the construction industry. Some industries were still relatively dominated by medium and large sized businesses: electricity, gas and water supply, mining and quarrying, manufacturing and financial inter-mediation. More detailed industry figures (available in the Statistical Bulletin) show employment was particularly reliant on small businesses in areas as diverse as real estate, recycling, computing and manufacture of wood and wood products.

In 1994, 99.4% of all traditional manufacturing firms employed less than 500 workers. Interestingly, the majority of people were employed in this 0-499 bracket. In fact the total percentage employed in firms up to 500 employees was approximately 73% which compared to 46% in 1986 is a significant increase (Employment Department). Therefore, the types of firms used in the research are major employers in the UK manufacturing industry. These figures changed little by 1998 where 99.2% of manufacturing firms were classed as SMEs and 49.5% (approx. 4.51 million) of all employees within that sector were employed in such firms.

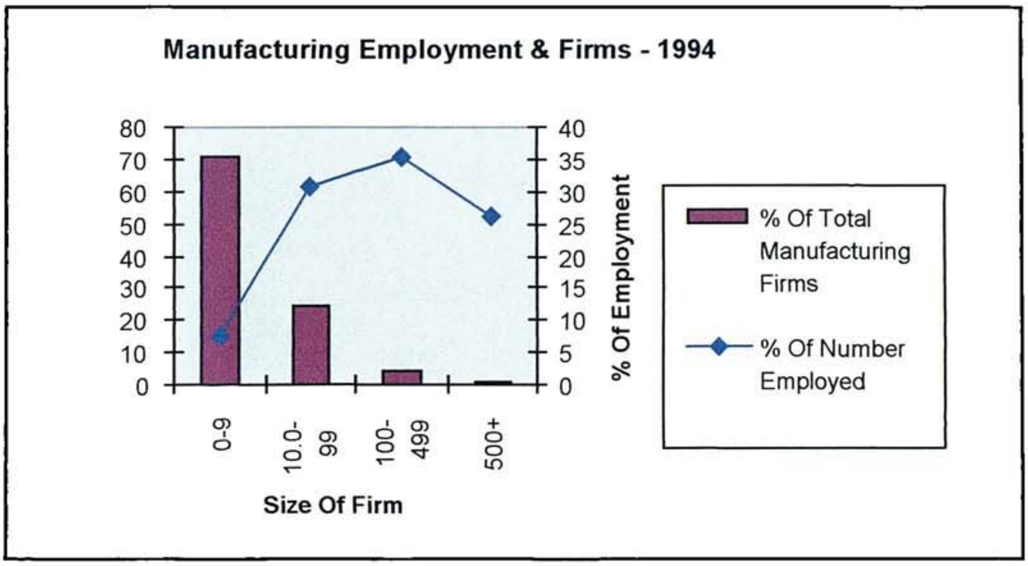


Figure 6.2: Manufacturing Employment and Firms (DTI Web Site)

6.3 INNOVATION PATTERNS

A recently published study by the DTI (Thomas and Jones, 1999) examines innovation patterns in the UK. The aim of the survey was to gather up-to-date information on the extent and characteristics of technological innovation activity in enterprises both in UK and other European countries. In the UK large enterprises were more likely to innovate than SMEs confirming the point made in Chapter 2. This was particularly true in the manufacturing sector where 83% of large enterprises, but only 48% of SMEs, were innovators. In terms of the type of innovation very few firms produced novel innovations that were radical in the market place. Enterprises introducing these accounted for 9% of the total. Large firms were approximately three times more likely to be novel innovators than SMEs, while novel innovation was more likely in manufacturing than services. Finally, and pertinent to the study is that 39% of manufacturing SMEs did R&D to achieve innovation. However, 61% used other activities such as the purchasing of capital equipment, external sourcing of technology, industrial design and training linked to technological change to achieve innovation.

6.4 CASE INTRODUCTION

It is clear that SMEs and mid-corporate firms play a critical role in the UK's economic development. The employment figures show that in manufacturing some 4.5 million people are employed in such firms over 10% of total employment in the UK and that of the total number of such firms 39% create novel innovations. The following section identifies five traditional manufacturing firms that play an important role in employing some of these 4.5 million people.

6.5 CASE 1: SU AUTOMOTIVES LTD. (SUA) A HISTORY

SUA is based in Birmingham and was founded in 1902. Its founders patented a constant depression carburettor. In 1947 it became part of the British Leyland Group prior to incorporation into the Rover Group. In 1988 SUA was one of many non-core businesses divested by the Rover Group. SUA was then bought by the Hobourn Group until in 1989 the Hobourn Group was purchased by Echlin Inc. Echlin Inc. is a US based company with a turnover of $3600million in 1997. By 1998 global resources encompassed more than 95 plants and customers in 106 countries. The company's historic growth was based on servicing the US automobile after-market needs. Echlin's principle product groups around the globe are clutches, brakes, exhaust components, ignition components and filtration items. This was supported by the inclusion in the group of SUA, Nobel Plastiques, Long Manufacturing Inc., Hobourn Automotive Limited and EPIC Technical Group Inc. The group expanded through growth and acquisitions (many of the companies named above), developing the theme of a global after-market component supplier. May 1998 saw The Echlin Group taken over by DANA Fluid Systems as part of its strategy to increase its acquisition of suppliers to provide an increasing link to the main car manufacturers without having to develop their own first or second tier supply business. (Financial Times 27/5/99). During this period DANA Fluid Systems was one of the world's largest independent suppliers of vehicular components and systems to original equipment manufactures and their related after-markets. DANA was also a leader in the development of modular systems technology. The DANA group (1998) included: Automotive components; automotive after-market; engine components; heavy truck components; off-highway components; industrial components; and leasing services for which DANA was awarded the Malcolm Baldrige Award. Across these groups DANA had over 80,000 people focused on finding innovative solutions for the diverse needs of its customers across the globe. During 1999 DANA operated in 33 nations on six continents. The company positioned itself to support customers in all major global markets. The ownership's by global organisations has always been at arms length. It has never led to major restructuring or changes in personnel the main concern and change has always been the financial situation and who in the company or in the parent makes final decisions on projects and developments.

6.6 SUA'S TURNOVER

Since 1994 turnover increased steadily (Table 6.1). Growth had been based on secure product developments. Investment in capital equipment had been in the region of 12% of sales per annum and investment in R&D approximately 4% of sales per annum. The company pays its manufacturing staff very well compared to its main competitors and other equivalent local manufacturing firms. The average local wage is around £4/hour were as SUA pay £6.28/hour. The staff are relatively well skilled with the majority highly skilled in traditional manufacturing techniques.

Year	Turnover - £
1994	£21 million
1995	£26.9 million
1996	£30.4 million
1997	£31 million
1998	£36 million (Actual 30 million)
1999	£39 million (More likely £26 million)

Table 6.1: SUA's Turnover 1994-1999

6.7 SUA'S ORGANISATION

At its peak, SUA employed in the region of 1200 employees. Changes in ownership, environmental concerns growing during the 1970s and 1980s and ultimately the changes in regulations for car emissions have impacted on the recent history of SUA. The carburettor since the mid 1990s saw a dramatic decline in sales (see Figure 6.3) as a core component of a cars engines and was replaced by more efficient fuel injection systems.

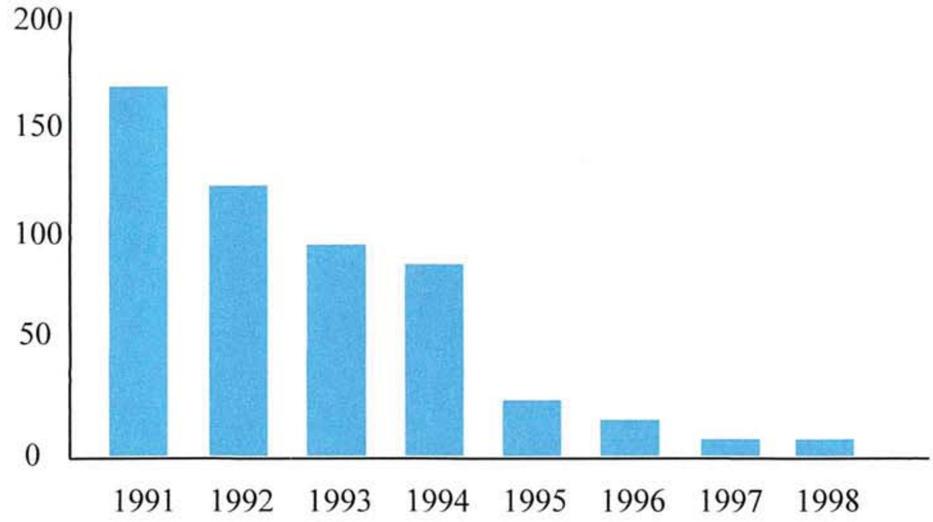


Figure 6.3: Decline of Sales of Carburettor

The changes left the company with a product they could not sell except to the army. At the start of 1998 the company had 284 permanent employees and 12 temporary employees. The 12 temporary employees fluctuated depending on the core lines set up. There were fourteen managers, one Managing Director and three directors: a Business Development Director; a Business Logistics Director; and a General Operations Director. There were 9 employees with degrees. 1 manager with an MBA and one other was 50% of the way through his MBA. Figure 6.4 shows the organisational structure at April 1997. The structure is based on divisions and particular systems.

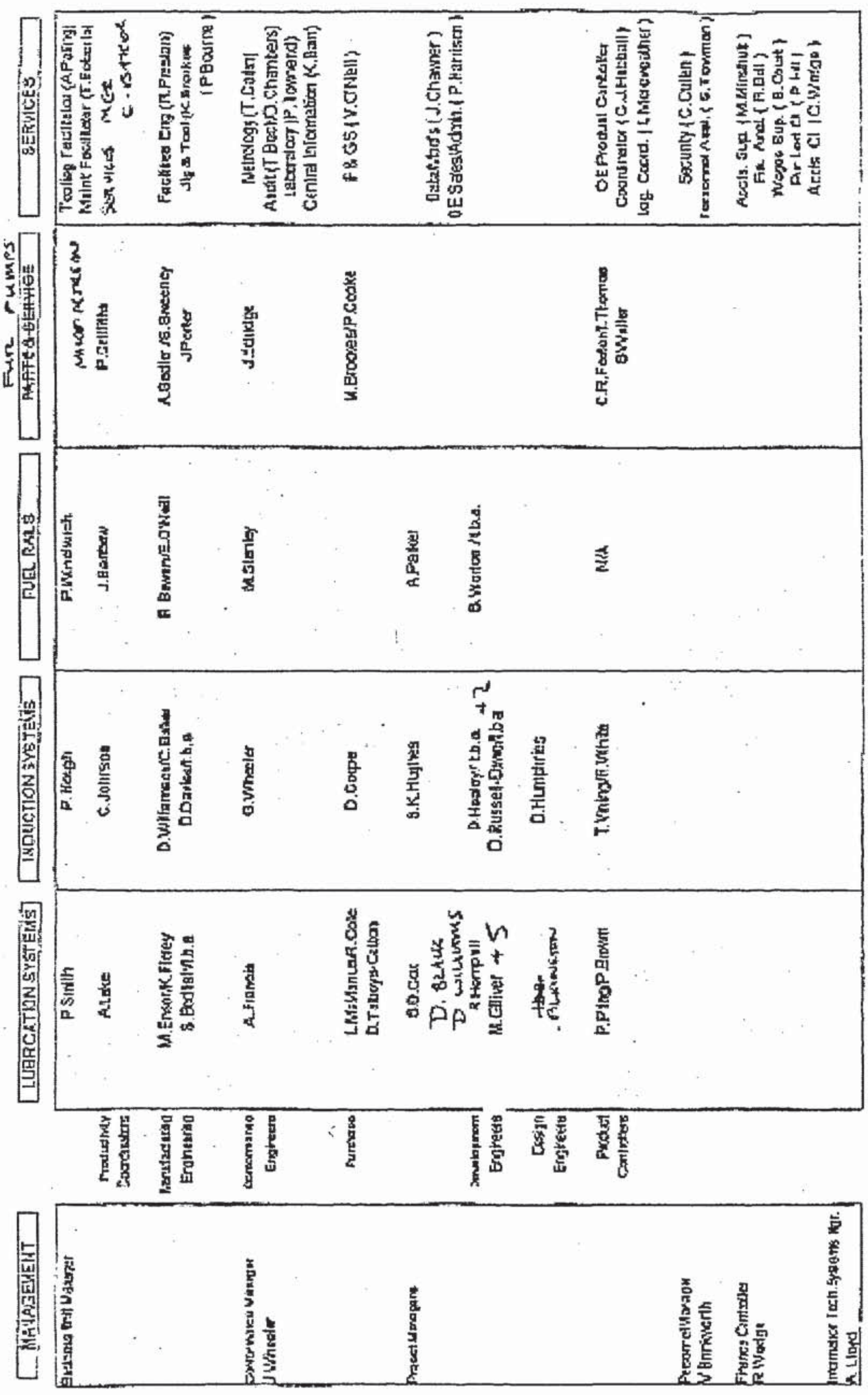


Figure 6.4: SUA's Structure

6.8 SUA'S MARKETS

94% of sales from SUA are of original equipment to automotive manufacturers. Supplying such organisations as Rover Cars, Ford Motor Company, Adam Opel, Rolls Royce, Lucas (Jaguar) and Triumph Motorcycles. Products include Throttle systems, Inlet Manifolds and Plenums, Engine Covers, Oil Pumps, Diesel Lift Pumps, Fuel Rails, VIS Valves and Fuel Induction Modules. How these match to the customers is shown in Table 6.2.

Customer	Products Supplied
Rover Cars/Landrover	Throttle Systems, Inlet Manifolds and Plenums, Engine Covers, oil pumps, Diesel Lift Pumps
Ford Motor Company	Fuel Rails, VIS Valves, Diesel Lift Pumps
Perkins Engine Company	Oil Pumps
Adam Opel	Diesel Lift Pumps
Rolls Royce	Throttle Bodies, Fuel Rails
Lucas (Jaguar)	Throttle Bodies
Triumph Motorcycles	Throttle/Fuel Induction Module

Table 6.2: SUA's Products Supplied to Customers

SUA was a 'stand alone company' (Adrian Parker, Project Manager), competing in a market dominated by very large, highly vertically integrated, global organisations. However, in 1995 the company was taken over by the growing Echlin Group. There was a strong feeling within SUA that significant opportunities were open to the company in terms of global markets. Presently the main companies SUA supplies are UK based and there has been a limited increase in new market opportunities. The same is also true with the recent buy-out by the DANA Corporation. These new opportunities are going to be very important to the company over the next few years as there are many changes in its current market base. Rover has played a key part in SUA's development over the past 20 years. SUA prior to 1990 was a business unit of Rover and once it had become independent SUA still gained much of its business through Rover. There were concerns regarding the take-over of Rover by BMW. BMW 'favours its own suppliers' and therefore there was the fear that Rover would be pushed to move away from SUA as a supplier. In 2002 the majority of all Rovers suppliers change to BMW suppliers which could potentially cut SUA's business by 30% and leave the company with serious problems which it may not survive. Project 2002 was set up to identify new business areas and develop new markets and businesses outside the strong ties with Rover. Seeking new outlets for current products was seen as key. Figure 6.5. shows the expected problem and the plan behind the project (Adrian Parker, Nov. 1998).

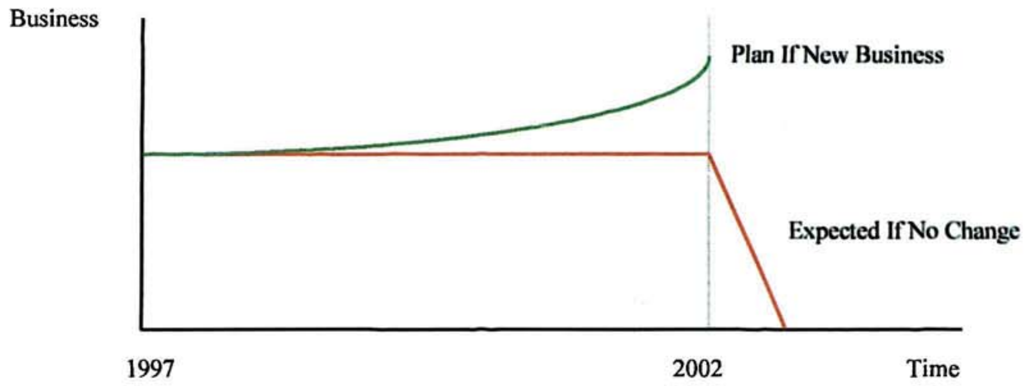


Figure 6.5: SUA's Business Forecast

6.9 SUA'S COMPETITION

Competition is quite broad in terms of the types of companies operating and producing products in SUA markets, such as Siemens and Bosch. In examining its competition SUA identified a major gap in the market and competition for the company should not be based on price but on integration and invention. Table 6.3 identifies the competition in SUAs two major business areas and the strategy that was employed up to 1998 in those businesses.

Business	Competition	Strategy
Throttle	VDO; Siemens; Bosch; and Delphi	Cost Based to New Technology (Electronics)
Oil Pumps	Vistian; GPM; Hanwah (Hungry); Yamada (Japanese); Aisin (Belgium); and SHW	Price based strategy - not system based

Table 6.3: SUA's Competition and Current Strategy in Key Businesses

The realisation was that new business had to be developed in a way that could compete with the competition and further the business in order to invest in new technology. Examining the market place and the competition had shown SUA that the oil pump market, which is SUAs key market '*....is made up of firms that are not solely in the oil pump market; which compete solely on costs; and which in some cases are moving out of the market*' (Adrian Parker, Nov., 1998). Competing solely on cost was no longer a viable option for SUA given it could not subsidise cuts through other business like many of the competitors were doing. Therefore, pump systems were identified as the way forward and the use of current technology could achieve this initial strategy. SUA identified a need, just as when the carburettor was made obsolete by environmental forces and legislation the new requirements for lower emissions and higher fuel economies were putting pressure on auto manufacturers. The throttle arm of the business was being outperformed by the competition. Technology moved more and more into the field of electronics and margins decreased every year. SUA saw itself becoming a 2nd tier supplier of throttle bodies and components unless it could form a strategic alliance with an outside party with the relevant understanding, knowledge and technology. If not then its market was likely to become one of supplying the leisure industry (e.g. Jet Skis). The competitors in the throttle market were large firms with strong electronics competencies given their product ranges.

6.10 SUA'S INNOVATION

Developing its innovative capacity became necessary due to the changes in legislative requirements from government, industry and Europe. 95% of industry changes are driven by legislation. Emission standards are ever tightening which is in part why the carburettor became obsolete and why improvements in the effectiveness and efficiency of fluid systems are important. If the legislation is not met the competition will take over. The plan was for a more proactive approach to new and future legislation by having company members participating in and tracking legislative agreements. The result of the environmental problems gave rise to the company developing what it called its Component Environmental Impact Assessment which provided a means for components to be analysed in terms of wastage, environmental effects, air, liquid emissions. All components are analysed in this way to make sure they comply with UK and European regulations.

Within SUA innovation has been viewed at three levels: product; process and new business. These levels played a leading role in the company's strategic plan to develop new innovative products based on current technologies. Various developments were underway based on fluid products and significant interest in new material and plastic programmes. Due to competition in the oil pump and cooling product market the company identified an area in which it could compete and offer certain advantages and this was fluid systems. This strategy fitted the DANA strategy of providing modular products and systems.

> *'Developments are now in the area of incorporating originally single products into a single systems'* (Adrian Parker, May, 1998).

The innovations and projects relating to new technologies and innovation within SUA fell into two main categories which are new technologies and new product systems. The developments in place during 1998-99 (see Table 6.4) involve either a joint venture situation with one of the automotive customer or team based networks within the organisation itself.

Current Developments	Project	Blue Sky Developments	Project
New Material Developments:	Plastic Throttle Body	New Material Developments:	Plastic Oil Pump
System Integration:	Oil Pumps with Integral Cooling Systems 'Purex System' Diesel Fuel Injection System Flow Regulators Thermostats Traction Control Throttle	System Integration:	Electric Motors with Cooling of Traction Motors Others

Table 6.4: SUA's Developments During 1998-1999

> *'SU Automotive gets, probably, one enquiry a month from external inventors who believe they have re-invented the carburettor. 99% of these are a waste of time once followed up'* (Adrian Parker, May 1998).

Research and Development is an important element in the company's strategic plans although the 4% of sale per annum spent on it each year has possibly been directed in the least profitable and market developing areas. However, changes in the market, environment, competition as well as customer requirements have provided SUA with the potential and opportunity to develop new products that reduce emissions and provide fuel savings which in turn brings a premium price for that particular product. Ford Motors for instance will pay on average an extra $10 per 1% fuel saving per unit.

> *'All the new developments have patents taken out... three have been secured and two are awaiting final confirmation'* (Adrian Parker, Nov. 1998).

The use of the patent system has, in recent years, increased at SUA and suggests that the company is attempting to secure its technology in the short term to gain maximum benefit when going to market. The belief was that *'this short term gain of patenting would begin to support future developments and especially incremental innovative developments'* (Adrian Parker, Nov. 1998).

New Technology	Domain
VCP	Public
ESP	with specific customers only
POP	Secret
EDP	with key customers
IFC	secret
TMS	with selected customers for testing

Table 6.5: SUA's R&D Projects Underway During 1998-1999

The IFC was launched early 1999 through an article in the Engine Technology International Journal which is an industry publication and is known to be read by the type of customers SUA expects to buy the product. This product was not however without its competition, the thunder was stolen by Hengst, a company that produces air filters for the automotive industry. They packaged their airfilter in a similar cover which incorporates coolers actually supplied by SUA. Management did not appear too worried by this development as SUA were able to provide a cover which includes all the required parts to form a complete system which had less overheads than Hengst. But again they are likely to compete on price. Unfortunately at this time I cannot discuss the developments except to say that those developments that are being prototype tested by key customers suggests that new market opportunities and new sales are a distinct possibility between 1999-2001. The first real internal innovative development to be fitted as part of a system for the automotive market was the Air Assist Fuel Injection unit developed for the Rover 75. This development began early 1997 and forms the basis of the cases study in Chapter 7.

6.11 CASE 2: DENIS FERRANTI METERS (DFM) A HISTORY

DFM is a long established privately owned company which was founded over 40 years ago producing materials manufacturing products for customers such as The Ministry of Defence. The company operates from a 3.2 hectare site and has 30000m of factory space (Figure 6.6).

Figure 6.6: DFM's Site

At the time of the interviews DFM employed 70 monthly staff, 200 direct operators (unskilled machiners) and 175 indirect hourly paid staff (tool makers/store men). Thirty of the staff were Quality Assurance, 5 staff and 1 manager were direct QA and 25 were indirect QA staff. The company gained Lloyd's Registered Quality Assurance with BS EN ISO 9001. EN IS 9001, ISO 9001 which expires 2001 and was approved May 1995 also DFM was B.T. Supplier Of The Year 1997 for its supply and manufacture of Pay-Phones and Quality Assurance Approval from the Defence Dept. March 1994. Traditionally the company has supplied finished products, assemblies and components to prestigious companies world-wide. The firm can undertake a large variety of mechanical, electronic and telecommunication contracts. The company has the ability to enter into a range of contracts from make to print through design and build to fully turnkey schemes involving project management, quality planning and logistics. The company in its history has worked closely with customers to improve quality, cost and performance of products. The company is also able to supply services related to product re-engineering, refurbishment and recycling

It was suggested that the firm is run as a 'Benevolent Autocracy'. Traditionally the manufacturing took the form of Batch manufacture although this changed mid 1990s with increasing use of work-flow manufacture. The firm generally has 12-15 main customers including GKN Perkins and BT (producing pay phones on Line Assemblies). The company has tended to manufacturer only to contract hence "if you took the customers away you would have difficulty identifying production of a specific product". Because of this lack of a specific product the company has never marketed any of the manufactured products it has never felt the need for a marketing department. It could be argued from a historical context that this has reduced its opportunities to enter into manufacturing products that could have made the company much stronger. The company turned down a possible contract with Dyson to manufacturing the vacuum cleaner because

> *'.....the opportunity didn't fit the current profile of the business and Dyson expected Ferranti to market the product as well'* (Gareth Williams, Feb. 1998).

There was also a similar occurrence with the Lynch Motor. DFM was approached to market the DC motor prototyped by Lynch and developed by London University. The motor had applications for boats, the leisure industry as well as small motorised vehicles because of its hi-power and very low running costs. Again the company was expected to manufacture and then market the product but DFM lacks a marketing department and had very limited competence in this area.

6.12 DFM'S STRUCTURE AND MARKETS

The structure (Figure 6.7) of the organisation over the period of the research changed little. The only changes came with individuals involved in the project discussed in the case (Chapter 7). Individuals in the organisation saw the structure as particularly flat with simple and short communication channels aiding communication and discussion.

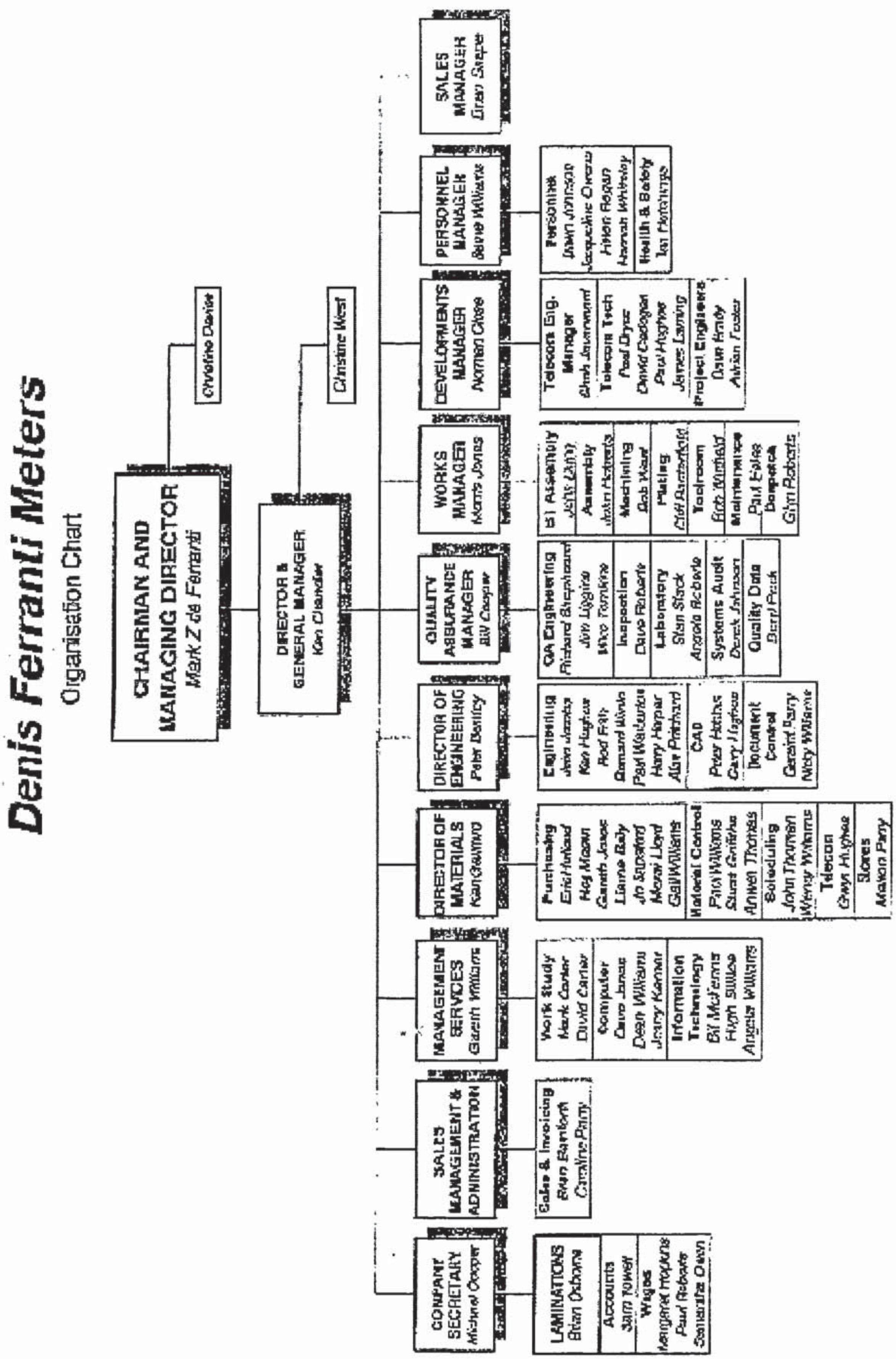


Figure 6.7: DFM's Structure

The company from the mid 1990s structured itself around 3 divisions. These divisions are particularly flexible in the type of products they may produce especially in relation to the company's objective that is to operate as a partnership contract manufacturer. The divisions have developed over the years due to the types of customers that DFM has supplied and where possible worked with. They are: Electronic; Payphone (Telecommunication); and Mechanical

These divisions have tended not to operate in isolation especially in the areas of electronic and payphones where areas overlap. The General Manager - Ken Chandler, oversees all three divisions. DFM's comprehensive range of machining, sheet metal, plating, painting, assembly and test skills arise from its long history in mechanical engineering. These skills have been used to manufacture a wide range of products ranging from diesel engines to payphone security products. In more recent years the company has diversified into the electronics market. By acquiring relevant skilled individuals and machinery the company is has been able to manufacture high quality PCBs including surface mounting, through-hole and automatic testing. The manufacturing skills have been put into place for the telecommunication market especially high volume products. Capabilities have developed over the years with the introduction of a powder coat paint plant, new CNC turning and machine centres and the move to modular assembly lines to provide high flexibility for medium to high volume manufacture. This has been very important given the company operates on a contract basis with customers and these customers can come and go at the end of any contract.

6.13 DFM'S STRATEGY

There has been little strategic awareness within the firm over its history. The company has operated as a large jobbing shop and has tended to rely on one or two major customers such as the MOD and BT. The firm has been very flexible in taking contracts crossing many product lines but all requiring mechanical, engineering and manufacturing skills. The company had never 'sold' its skills to customers or considered real innovative improvements in relation to process or product development. In this sense the firm has never been in a position to undertake product development for customers in the same way as SUA. A strategic view of its market place and position in the manufacturing industry was still rather limited. However, the realisation that internal processes were poor and relying on one or two major contracts to keep the firm in business was extremely risky meant that the firm began to slowly change. The company considered a strategic approach to its businesses by developing individual business strategies for each of the divisions identified but more importantly to sell itself as a partnership contract manufacturer to potential customers. The main thrust of this strategy was to appoint a full time Marketing Manager. His role was different from his predecessor in that he no longer spent his time looking at sales figures. He has also spent a great deal of time off site meeting with potential customers. By the middle of 1999 he had only been in the job a few months. His first job was to update the company brochures which were nearly 20 years old and set up a small web-site for potential customers to obtain information on DFM and what it can offer.

6.14 DFM'S INNOVATION

DFM has had a policy of working closely with external sources to produce and acquire innovative products and processes. However, there have been few efforts to collaborate with customers, suppliers or to develop innovation networks. The company has basically operated as a large 'jobbing shop' producing a wide variety of low-technology engineering products including BT pay phones. At the beginning of the research managers were considering replacing the existing MRP system with a programme which would make control of the manufacturing processes simpler and more efficient. The company had relied on the MRP (Materials Requirement Planning) system since the late 1970s to aid materials provision and stock control. This assisted in making the materials department the main beneficiary of the system providing few benefits to production and engineering. The old MRP system had many indirect systems attached to it to produce reports. However, these had never been integrated to provide company-wide benefits and there was no means of viewing what was happening on a production/manufacturing line at any time. The old system was viewed as a legacy system because it was missing knowledge; the knowledge was inherited and in parts out-dated; and development of the system was costly and very problematic. Another concern was that the existing MRP system was not Year 2000 compliant.

Unlike all the other cases DFM has never been seen to be innovative or in general take business decision risks in terms of technologies. New technologies have only been accessed when customers have required it. New process technologies have been purchased when the customer is supplying long term business and may be used to undertake other business. The project discussed in Chapter 7 may well have scope for integrating new technologies into the manufacturing process.

6.15 CASE 3: OTTER CONTROLS LIMITED (OCL) A HISTORY

OCL is a privately owned company with an annual turnover of approximately £20 million and the objective is to double sales to 60m by the year 2000. The company was founded in 1946 and growth led to five UK sites and a work force of just under 500. The business is based on the manufacture of control devices for the automotive and small domestic appliance industries. OCL is a successful exporter and supplies products to over 40 countries with 85% of cut-outs exported with 25% of sales going to the 'two most competitive and quality conscious markets in the world, Japan and Germany'. Customers include: Aston Martin, Daewoo, GM, Honda, Hyundai, RR Motors, Bosch, Ford, Jaguar, Nissan, Toyota, VAG Audi. Table 6.6 provides details of number employees, sales, units sold and capital between 1984 and 1999.

	1984	1987	1990	1993	1996	1998	1999
Employee	669	740	789	723	819	862	under 500
Sales	£9.5m	£13.2m	£17.3m	£19.7m	£27.2m	£31.5m	NP
Units	22m	30m	48m	55m	84	96m	NP
Capital	£5.4m	£8.2m	£13.lm	£14.lm	£12.0m	£13.1m	NP

Table 6.6: OCL's No. of Employees, Sales, Units and Capital By Year

The sites in Buxton, Wales and Scotland use automated manufacturing to produce products using in-house designed and assembled machining technology. Five directors of whom the Technical Director had the prime responsibility for technological development ran the company through the 1990s. The Chairman and major shareholders have tended to have a clear vision of the future for OCL and the fundamental role technology plays. Although, in terms of technology, business objectives have been set out but the mission and strategy have been implicit and have not been clearly communicated to all key personnel.

6.16 OCL'S STRUCTURE, PRODUCTS AND MARKETS

During the 1990s the structure of OCL changed three times. The initial reason being to meet distinct changes in corporate strategy and later due to failures in new product developments. The structure moved from a functional structure which added an electronics department to a product based structure and then back to the structure that was in place during the research which no longer included the electronics department and was once again functionally based (Figure 6.8). Missing from this structure is the TMS department which will be discussed in the case (Chapter 8).

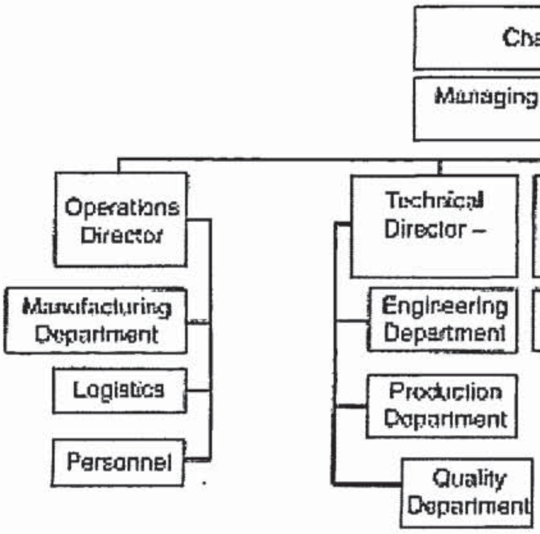


Figure 6.8: OCL's Structure

OCL as a company has tended to be subdivided into strategic business segments. Each has its own specific characteristics although there are links between the segments technologies. These businesses are:

- Kettle Controls
- Motor Product - DC Motor Cutouts
  AC Cutouts
- Sensors

Each business has required a specific set of capabilities (e.g. the understanding of bi-metals for cutouts) and as we shall see each is affected by the technologies within the industry/business sometimes to the company's advantage and in some cases as a disadvantage. Sensors and electronics have become declining markets for OCL. Kettle controls and motor products are the main markets and this is due to the non-diversification strategy being followed within the company. OCL's core products are snap acting bimetallic switches. The design and manufacture of these requires a number of technologies. OCL is differentiated by its ability to apply all of its technologies in combination, rather than excellence in any one technology. The DC cutout market is highly concentrated and OCL has only two significant competitors: Texas Instruments and STRIX. OCL also produces AC cutouts for a wide range of products in the domestic appliance market: battery chargers, cable reels, hair dryers, transformers, and washing machine motors. This market is highly fragmented and represents just 10% of OCL's turnover. The water heating market is very much narrower with nearly all sales being into kettles. Kettle controls account for 30% of turnover and this markets is also highly concentrated with only one direct competitor, Strix, a company approximately the same size as OCL.

6.17 OCL'S TECHNOLOGIES

Although OCL's business continues to be based on a well known principle of bimetallic switches a number of technologies have been used in product design and manufacture. OCL has a tradition of incremental product development based on a deep understanding of a wide range of technologies which is unusual in a SME. The company has developed technological competence in the following areas: Snap-acting bimetallic switching; Materials including bimetals, pressed metals, and contact metals; Insert moulding; DC and High-Frequency welding; Ultrasound welding; Infrared sensing; Encode/Decode software; Small RF (Radio-Frequency); antennae/transmitter development; Thick-Film circuitry for sensors; and Electronic-Based pressure and temperature sensing. OCL has also had access to microprocessor control technology that is now used in process automation and for the development of bespoke control systems. Microprocessor control has been used in combination with other technologies such as thick-film sensors to innovate new products. The core competence (Prahalad and Hamel, 1990) within OCL is the integration of product and process development with its production capabilities. For example, the manufacture of bimetallic switches integrates applications knowledge with a deep understanding of snap action and contact technologies. These are combined with unique production skills which enables OCL to manufacture individual switches reliably, quickly and cheaply. The development of new products has been based on incremental improvements of existing products or using a generic technology in a new product. Hence, commercialisation has, to a large extent, drawn upon existing skills.

A change in corporate/business outlook in the early 1990s led to investment in R&D to develop radical new products. This thinking has changed over time and is now centred on developing traditional products into new areas. During this period the motor companies (customers for cut-outs) have engaged in world-wide sourcing of components and have forced a 30% reduction in focusing on technological issues which may affect the organisation. This allowed the integration of technology and technology strategy into the corporate and business strategies of the organisation and placed technology at the policy and decision-making level.

Ultimately the objective has been to increase the potential for competitive advantage and innovations.

6.18 OCL'S HIGH TECHNOLOGY PERIOD

The early 1990s at OCL saw the Board as the driving force in the search for external sources of technology. The Technical Director was responsibility for identifying potential partners and reporting back to the Board who decided whether or not to proceed with an alliance. Managers and engineers are constantly involved in the improvement of current products, processes and technologies which makes it difficult to take on additional projects. Hence, the main reasons for seeking alliances between 1992-1996 were as follows: the market for automotive cutouts was expected to decline in the late 1990s with electronic technology replacing bimetal technology. It was believed that OCL could not compete in the semiconductor market and therefore sort alternative products and markets:

- a drive in kettle controls was for cost leadership and differentiation through new rotational cordless connectors
- insufficient time to devote to new projects; to supplement in house knowledge and skills
- more attention to new product development by examining emerging technologies such as RF antennae, grinding technology, and software algorithms; electronics
- accessed specialist expertise from universities.

In seeking to establish potential alliances the OCL Board set very broad objectives: To acquire new technologies; and to develop new products. New products and technologies had to fit the following requirements: ideally in an existing or related market; complementary to OCL's competence in mass production processes; and the technologies should be protected by patent. The Technical Director initiated two radical projects: Tyre Monitoring System (TMS) and the Depth of Anaesthesia Monitor (DAM). Unlike the other cases the project outlined in Chapter 8 began in the early 1990s. An inventor approached OCL in 1992 with a device for sensing the pressure of pneumatic tyres. The prototype system used bimetal technology in which OCL has a strong competence. The primary objective was to access an emerging technology and develop a completely new product. However, after evaluation by the Technical Director, testing the sensor on his own car, it was felt that a device based on bimetal technology was unlikely to be acceptable to automobile manufacturers (Jones and Smith, 1997) as it stood although the potential for such a product was viewed as high. The idea/invention was viewed by the Board to fit OCL's strategy to develop new technologies and products for future competitiveness. The Board was keen to proceed given the enormous commercial potential. At this stage OCL offered the inventor a sum of money to license the idea given that he had already patented the idea. OCL' engineers (Andy Derbyshire - Production Development Engineer, Andrew Bromley - Assistant Electronics Manager, Chas Kilby - Development Engineer, and Mark Guyer - Product Manager) were given time to work on the TMS in conjunction with the inventor as well as continuing on other project developments within the organisation for initially 6 months. This feasibility study, raised an electronic solution as 'more practical'. OCL subcontracted the work to a division of Salford University Business School (SUBS) called CAMPUS due to limited internal knowledge and expertise in electronics. CAMPUS evaluated OCL's work with the inventor and was asked to analyse and assess the potential of existing technology in the market place. The report from the university was positive in terms of what could be achieved through electronics technology although it would require a large funding bill and the development of key RF antennae technology. The report led to OCL contracting the university team to assist in the development of an electronics transmitter/receiver technology. The network from the point of view of the team and OCL was too focused on the university. During January 1993 management realised that there were a number of problems: poor appreciation of the scale of the project; poor appreciation of the technical problems involved in the system; and misleading feedback from the university team, regarding the stage the TMS was at. OCL at the time had negotiated a deal to provide a prototype to an automobile manufacturer. The deadline was missed which consequently meant credibility was lost with this manufacturer. With the limited returns on the investment at that time led to the decision to 'wind down the university involvement' and a young engineer with RF competence was recruited and the project brought in-house. This stage was supported by the inclusion of OCL in a European Commission ESPRIT Programme consortium looking specifically at RF antennae technology (a key part of the sensor) and not tyre monitoring systems. This link was fostered through a chance meeting with a Schlumberger engineer at a sensor conference at Southampton University. OCL did not have the necessary assets to co-ordinate international collaborators. Collaborating in this was with Schlumberger meant that OCL could access resources it did not have. The external orientation of the network therefore increased with the ESPRIT Programme (which provides money to support half the development whilst the rest is paid by the organisation as well as setting milestones) playing a role as well as electronic suppliers. Between 1993 and 1996 the project was on and off many times due to technical problems with the transmitter and battery life.

OCL restructured itself moving away from its traditional functional structure. Rapid product life cycle led to a growing emphasis on a product structure based on engineering, accounts, marketing and production being reorganised into three divisions: Automotive Products, Domestic Appliances and Operations. At that time David Smith moved from production manager to motor products manager whilst continuing to oversee the TMS project which was now part of the electronics department. This created four product managers and radically integrated knowledge and expertise into the product areas. Employees were grouped together according to products rather than their functional areas. The main objective of the change was to improve communications between marketing, engineering and production as well ensuring that everyone feels 'closer to the customer'. Marketing activities were divided into sales within different product areas, while marketing was given more involvement in the development of new products as well as the acquisition of market information.

The revised strategy attempted to focus attention on 'value-added' to existing products rather than diversification. The organisation began to concentrate on integrating products such as bi-metal and brushcard to create automotive systems. Thus offering the 'complete service' (cut-out and brushcard) and increasing the value of their component from approximately 20p for cut-out to £1 for the complete system. OCL managers still intended that the company should diversify but this would be more 'focused' than their efforts with the Tyre Monitoring System (TMS) and the Depth of Anaesthesia Monitor (DAM). The change in structure and management's belief that bringing knowledge and expertise together would solve the technical problems of the TMS appeared to fail. Reliable battery life was a main stumbling block to the TMS as well as the failure of a number of sensor and electronic developments and as a consequence the Technical Director, under pressure from the board, decided that the project should be terminated. This led to abandonment of the TMS in November 1995 and resulted in 15 electronic engineering staff losing their jobs. However, the ESPRIT Programme meant the company had to keep one electronics engineer on the project until the end of 1996 - '*We had to continue with the ASIC development of the TMS in order to meet the requirements of the ESPRIT Programme*' (David Smith, May 1997).

In September 1996 OCL restructured itself again as senior managers decided to return to a functional form of organisation (Figure 6.8). This also saw Bill Priece the Technical Director promoted to Managing Director and David Smith was promoted to Technical Director. The company focused on its core competencies in bi-metallic technologies rather than seeking to develop radical new products especially with the motor companies (customers for cut-outs) engaged in world-wide sourcing of components. A 30% reduction in the price of cut-outs was forced during the mid 1990s. OCL was able to respond to this pressure because of its relatively low labour costs and because the company had invested heavily in automation which enabled them to remain competitive in world-wide markets. Also, future automation equipment will be 'bought-in' rather than manufactured on-site by the company's own craftsmen. By May 1997 there were still 100 staff employed on product and process engineering concepts for the future' and the main objective was still to double sales to £60m by 2000. According to David Smith many of these are involved in fairly mundane activities and in terms of what would generally be accepted as R&D there were probably about 25 highly qualified engineers. David Smith estimated that innovatory activity was 90% incremental and 10% speculative. As Technical Director, David Smith during these changes in 1996/1997 managed to divert resources to support the TMS project during the finalising of the ESPRIT Programme. This led to some significant breakthroughs and the potential to now develop a product that could be manufactured for market in a relatively short space of time. Hence, the case in Chapter 8 follows this period from 1996-1999 in the TMS's life and begins with a mapping of the networks briefly discussed here.

6.19 CASE 4: DUFAYLITE DEVELOPMENTS LIMITED (DDL) A HISTORY

DDL is based in St. Neots and was founded in 1955 to realise the commercial potential of paperboard honeycomb. The paperboard honeycomb was originally patented in 1890 and formed the basis of Christmas decorations. In 1943 George May patented a new application for the honeycomb for military use. One aircraft that used the product was the Mosquito aircraft used in the Second World War by the allies. It was George May who became one of the founding members/directors of DDL and the first division DDL Honeycomb. In 1972 The Hanson Group (known at the time as The Wiles Group) bought DDL. After the take-over by Hanson, DDL diversified into new divisions including Panel and Packaging Divisions. The company however was being run as a cash cow for the Hanson Group and very little investment was being made into the company whilst it was successful. The early 1990s saw a change in the fortunes of DDL as a cash cow that was not helped by the lack of investment by the owners. Therefore in 1993 a team from the Hanson Group (SLD Holdings Limited) put together a buy out package and were successful. The buy-out was backed by venture capitalists Electra Fleming. An indicator of the change at DDL is shown by the fall in turnover between 1990 and 1994.

Date	Turnover (£millions/year)
1989 - 1990	£9 million
1992 - 1993	£5 million
1994 - 1995	£4.8 million
1996 - 1997	£4.5 million

Table 6.7: DDL's Turnover

Table 6.7 shows turnover at DDL from 1987 to 1997. The figure of 1994-1995 was inflated by a £1 million sale of machinery to South Africa and Spain. 1995 was a difficult period in DDL's history as the company was struggling to pay the venture capitalist that had invested in the buy out in 1993 and was unable to invest in new products, technologies and process technologies to develop the business.

6.20 DDL'S STRUCTURE

The company has always been structured into product divisions. The five divisions being honeycomb, panels, packaging, construction and fire protection. In 1998 there were three directors plus the Managing Director and each division had its own Business Manager. The structure was flat with only four layers of communication, directors, managers, supervisors and operatives (Figure 6.9). The structure tends towards a matrix form (Burns and Stalker, 1961). Directors were viewed to play an important role in conflict resolution, authority is based on employment contracts and loyalty is strong within the company with the majority of staff being with the company for 15 years or over (Mike Burnell, Dec. 1998). Anthony Wascrop communicates directly with each divisional manager and then individual directors and then a management structure. The Operations Director's role is mainly a link to production, engineering and the logistics of these key areas in the manufacturing process. The Finance Director overseas the marketing and sales of the organisation. The role crosses the boundaries of the divisions as the Finance Director is formally linked to the business development manager who clearly examines the internal business in relation to what the markets and the external environment is doing.

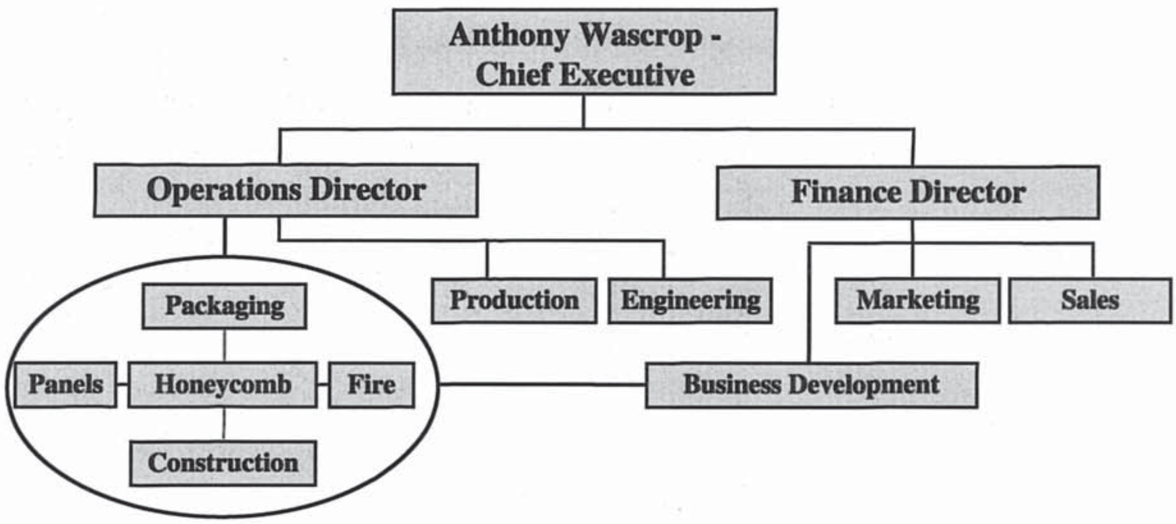


Figure 6.9: DDL's Structure

A revised management structure was put in place in 1995 with a new Chief Executive, Operations Director and changes in the finance and accounts department. There was also a reduction in the number of employees within the organisation. In 1990 there were 140 employees this was already being reduced during the period of the buy-out to 72 and in 1995 another 10 staff made redundant. Also two major customers who had been connected with the company for 25 years took their business elsewhere. DDL at the start of 1998 had 62 employees with 90% of sales arising in the UK. The company currently views the UK market as having little opportunity for growth in existing product areas. At the start of 1998 the Sales Director was made redundant and a new marketing manager was recruited.

The fortunes of DDL looked bleak. However, a product invention that had been developed in 1996[1] but not followed up was the Honeycomb packaging. The packaging was based on two pieces of side card with a honeycomb centre between them. Making it both extremely light but also competitive with polystyrene packaging.

Anthony Wascrop came from a marketing and sales background and therefore involved himself heavily in growing the export business. The first market to open up abroad was the Emirates developing into a £1/4 million business a year from the sale of fire protection products. This development of new markets has been slow and it was identified that the marketing of the company and products was under resourced and suffering. Too much emphasis was being placed on their financial aspects of products and markets. The decision was made by the CE to remove the Sales Director and appoint a new Marketing Manager. He has therefore spent time selling the potential of the products to China, South Africa, Turkey and The US as well as Sweden and Europe generally. 1996 saw DDL's exports at 5% and in 1997 this rose to 11%. The strategy was to increase this percentage and in attempting this, during 1998, two extra production staff were taken on increasing the number of employees at DDL - '*...........the first rise for 4 years*' (Anthony Wascrop, Jan. 1998).

6.21 DDL'S PRODUCTS AND MARKETS

The manufacture of paper honeycomb is not complex. It is manufactured from industrial rolls of paper which are 2m high, 1m wide and weigh around 1 tonne. The paper is unrolled and cut into equally sized sheets, but when the sheet has been cut its upper surface is glued before the next sheet is cut and put on top. This process continues until typically 100 layers have been built. The block of paper is cut width ways into strips and when the sheets are pulled apart the honeycomb patter can be seen. The honeycomb pattern is created at the gluing stage. The glue is applied in narrow strips along the length at alternate positions on each layer of paper and the whole process is continuous and automatic. By expanding the paper honeycomb out horizontally it becomes very rigid. Paper or card surfaces can then be glued onto the top or bottom or both to form a pad. These pads can be cut, folded, crushed and glued to corrugated cases to provide very rigid packaging. The manufacture of the paper honeycomb provides

[1] In 1996 the investment was commissioned by way of increasing turnover through a reduction in fixed costs for the development of the machinery to produce the product. Money was saved and costs cut in a common sense way.

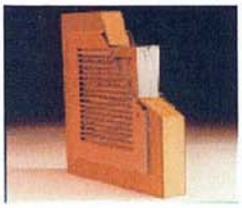
application to a number of markets. DDL currently operates within five markets which are Honeycomb, Packaging, Construction, Fire and Panels.

Honeycomb - This part of the business is a continuous thread running through the company's history and its product range. DDLs honeycomb is used in the control and spread of fire, damage to building foundations, it plays a role in the packaging of fruit and packaging. It forms the basis for the other divisions within DDL. It is also 100% recyclable as it is made of paper/card.

Panels - This part of the business has been running for 25 years and today offers one of Britain's largest panel range, from partitioning to display to road vehicle doors. The main benefit in these areas is the weight advantages. Panels can be produced that are fire resistant, insulated, rigid, detailing and ultra flat.

Packaging - This division produces products to protect goods as varied as apples, pears, tomatoes, Easter eggs, dishwashers, whisky, paper, textile fibres and plant food throughout national and transcontinental journeys from manufacture to user. Also within the range are Falcon void fillers to fill the spaces between lines of pallets to prevent loads from knocking together and being damaged in transit. Also DDL Packaging Support pads, made to each customers requirements, protect by withstanding distributed loads of many tonnes per square metre. This market is season sensitive and dependent on crops.

Construction - This division grew out of a the versatile use of the honeycomb.. DDL honeycomb clayboard was designed to prevent damage that may arise when the content of water in clay soil changes, the resultant expansion and contraction can damage buildings irreparably. It enables builders to engineer a void in which soil movement can occur harmlessly without dangerous stresses being transmitted to the structure.



Fire Protection - DDL has certified fire protection products which include the unique Honeycomb Fireblock and Fireblock Ultra for protecting doors and ventilation openings, and the lightweight, high performance. The technology behind nearly all these products is the intumescent technology. This technology swells rapidly in fire conditions thus sealing apertures and preventing the spread of fire and smoke.

Many of the divisions turnovers are reliant on just a small number of large customers. The Honeycomb division is one such market which has 2 customers which provide £750K of turnover, with 4 others supplying just over £100k the rest vary over a broad sphere from 10s of thousands to £70. This means that of a turnover of £1.5 million 50% is made up of 2 companies out of 130 - a loss of these customers could create a serious problem for the division.

6.22 DDL'S INNOVATION

Innovation at DDL has relied on incremental changes to current products and processes for a long time. The main changes have come in the purchase of new technologies to improve the main process behind the honeycomb. The acquisition of new gluing machine, allowed greater flexibility in how and where glue is applied to sheets, potentially identifying a competitive opportunity. Environmental changes in the destruction of polystyrene in the late 1990s meant that European customers began looking to purchase less costly recyclable packaging. Hence DDL developed new forms of its honeycomb packaging to replace polystyrene and attack European markets. Machinery has tended to be the main way in which processes can be improved and opportunities met in new market areas with the core competence being the development of the honeycomb board. However, the case gives a new perspective on DDL. With a new MD in 1997, the drive has been to be more market orientated in order to develop market opportunities and strengthen sales world wide. Therefore, the company has examined new software systems that would aid the information and production process within the organisation to support marketing and strategic decision - making. The case (Chapter 8) also highlights the impact of learning on individuals with regards to new technologies.

6.23 CASE 5: WANDSWORTH ELECTRICAL LIMITED (WEL) A HISTORY

WEL is a privately owned manufacturing company with some 30 shareholders and over 200 employees. The company was founded in 1904 by three members of the staff of the firm of J.H.Tucker Limited. Tuckers had been manufacturing wiring accessories in Birmingham since 1892 and no longer exist as a separate company. Competition has continued to be small as the number of companies manufacturing only wiring accessories has never been large and WEL is probably the oldest to have maintained its independence, almost certainly in the UK and possibly in the world. The company spent its first 50 years in premises in the areas of St. Pauls Square and the *Jewellery Quarter* near the centre of Birmingham, interrupted by the complete loss of its factory and contents during a wartime raid in 1942. WEL was then heavily engaged in production work for the Admiralty, which was resumed in various temporary premises until it moved to Woking in Surrey during the period 1952-54. The company generates an annual turnover of over £11M, which is achieved across a diverse product range which can be broadly split into 4 categories: Electrical accessories; hygiene equipment; call systems for hospitals and prison establishments; and medical equipment.

6.24 WEL'S STRUCTURE

The structure of the organisation prior to the research undertaken was based around four directors. The structure appears very flat in terms of departments and is functional rather than divisional/product based. The structure although flat did limit the communication between directors and customer needs and were not valued to the degree that they should have been. For this reason *'market areas and product planning was limited'* (Gary Stevens, Dec. 98). Figure 6.10 (Stevens, 1997: 68) shows this structure.

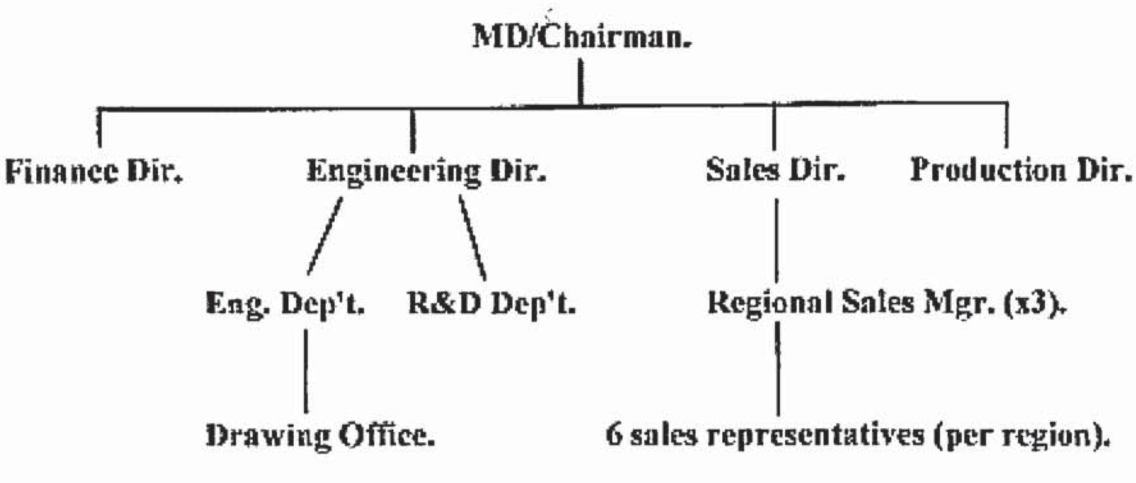


Figure 6.10: WEL's Structure

6.25 WEL'S PRODUCTS AND MARKETS

6.25.1 Electrical Accessories

Aston University
Illustration removed for copyright restrictions

This is the core business of the company, where they built a reputation for quality and a range of finishes unrivalled in the industry. The electrical accessory market is worth approximately £284M per annum, with the major portion of this being made up by sales of moulded plastic accessories (domestic switches and sockets). WEL have never been involved in this segment of the market, but have effectively carved out a niche in the metal plate accessory market, producing high quality finishes in polished brass, bronze, chrome and stainless steel. Consulting engineers, interior designers and architects specify the products. The other large segment for the range of accessory interiors is the 'OEM' market - where manufacturers of original equipment include a WEL accessory within their own product, this segment represents approximately 50% of the accessory turnover for the company. The outlook for the wiring accessory market predicts a steady 5% growth year on year through to the millennium. The rise in turnover between mid 1980s and 1990s is shown in Table 6.8. The biggest threat has been coming from the Far East, where imported electrical accessories are under-cutting the British and European companies considerably.

	1986/87.	1995/96.
Total. £M	3.45.	5.90

Table 6.8: WEL's Accessory Turnover 1986/87 - 1995/1996

6.25.2 Hygiene Equipment

The range of hygiene equipment marketed by WEL can be split into the following categories: Warm air hand dryers; Water macerators; Urinal water saving units; and Sanitary incinerators. Turnover between the mid 1980s and mid 1990s has increased as shown in Table 6.9.

Aston University
Illustration removed for copyright restrictions

The sanitary incinerator product range was first introduced in 1955. The water macerator replaced it in the late 1970's. The macerator was a smaller, compact unit and utilised a grinding mechanism to crush the sanitary towel that could then be safely passed through the drainage system without fear of blockage. The water macerator range was a revolutionary solution to the problem of sanitary disposal and quickly became market leader under the *water bunnie* brand name. During the 1990s this product range suffered dramatic decline in sales, due to cheaper substitute services (sanitary bin collection services).

The warm air hand dryer product range consists of 5 models, all of which are factored from a company called Anda Products Ltd (the largest hand dryer manufacturer in the UK and second in the world). Anda also manufacture the water macerator under license for WEL. The hand dryer tends to be specified by the same groups who specify electrical accessories.

The urinal water saving device is also a factored product from a company in New Zealand who purchase the water macerator for sale into the Southern Hemisphere. This product was introduced onto the market in 1990 but struggled due to its high selling price.

	1986/87 (£M)	1995/96 (£M)
Hand dryers.	0.380	0.900
Water macerators.	1.670	0.550
Incinerators.	0.124	0.050
Water savers.	0.004 (1989/90)	0.020
Totals :	2.178	1.520

Table 6.9: WEL's Hygiene Equipment Turnover 1986/87 - 1995/1996

6.25.3 Call Systems

The hospital call system range of equipment represents a major area of growth for WEL during the 1990s. The introduction of new technology has seen the turnover of this product range more than triple between the mid 1980s and mid 1990s as shown in Table 6.10. The product range in that time has gone from a simple call button and bell system for patients to summon the assistance of a nurse; to a software-based communication system allowing 2 way speech links between patient and nurse, including radio and television entertainment systems at the bed head. The market has seen increasing introduction of new competitors particularly from European nurse call system manufacturers, increasing the need for continued product development and market monitoring. The call system product range for prison establishments is a simple variation of the nurse call system technology, but the hardware is obviously tailored to suit the environment! WEL have been market leaders in this particular segment for many years, due to their close working relationship with the Home Office Directorate of Works for continued product development. However, with the introduction of the private sector into this market place (designing, building and running prison establishments), the Home Office influence has diminished - leaving the door open for smaller companies to offer cheaper alternatives to the WEL product range. The company now face a decision on whether to re-engineer this range to reduce costs, or to divest the range.

	1986/87 (£M)	1995/96 (£M)
	0.800	3.000
Prisons.	0.200	0.400
Totals :	1.000	3.400

Table 6.10: WEL's Call Systems Turnover 1986/87 - 1995/96.

6.25.4 Medical Equipment

The products encompassed by the *medical equipment* range include; Medical examination lamps; X-Ray viewing screens; Controlled drugs cabinets; and Heated lotion cabinets. The turnover have overall increased as shown in Table 6.11.

Each product is manufactured by WEL and this has been the case for over 30 years. The medical examination lamp range has received the major investment, with a new range of redesigned lamps launched in 1989 to coincide with a new British Standard (BS4533).

The main outlet for the X-Ray viewing screen market is through the health authorities. The outlook for this product is not clear, with the introduction of digital imaging in hospitals in place of the more traditional X-Ray films.

The application for the heated lotion cabinet is in the operating theatre area of a hospital, where fluid used for swabbing purposes needs to be stored at body temperature. The market is relatively small for this product, and due to the design and construction of the product, the scope for a replacement market is limited.

	1986/87 (£M)	1995/96 (£M)
Exam lamps.	0.051	0.260
Others.	0.450	0.310
Totals :	0.501	0.570

Table 6.11: WEL's Medical Products Turnover 1986/87 - 1995/1996

6.26 WEL'S INNOVATION

Since 1987 the company has pursued a policy of "market penetration" and "market development"; increasing the size of the sales force from 10 to 20. In that process the sales force was restructured, initially by creating two regions (North and South) with the responsibility for each region resting with 2 regional sales managers (former sales representatives promoted). In 1994 this policy was further expanded with the introduction of a third region (Central region) and the promotion of another representative to regional sales manager. Although this policy initially showed encouraging signs, it was perhaps in hindsight due also to the fact that the construction industry was enjoying a "boom" (1988 - 1990).

The approach to new product development was on an *ad-hoc* basis, with no obvious responsibility for new product development resting with any one individual. In addition to this, the structure did not cater for a laid-down procedure for carrying out new product development in an innovative and planned manner. Most of the examples of developments over recent years have been as a result of either: a "market follower" strategy - where new product innovations by competitors have been copied; or modifications to existing product ranges enforced by new British Standards or through the availability of new production methods. Although both of the above strategies are perfectly legitimate courses to follow, in today's climate of shorter life-cycles, rapid advancement in technology and increased global competition, the need for a deliberate "new product development" policy has never been greater. During the early to mid 1990s, WEL attempted to re-position itself within its markets to develop new products and where possible be innovative internally as well as in relation to products. Many product changes and innovations are triggered by British Standard changes within the electrical industry and in effect are the key tests of any new product or innovation. Innovation and product development in general begins with an approach from a potential customer or possibly a current customer. A feasibility study is initiated by the R&D department at WEL - led by Graham Massey, the Engineering Director. The main criteria for the feasibility study will be formulated by both parties and depends on WEL's abilities and customer wants in relation to regulations and British Standards. A product design team is then set up to see the project through to completion; this team normally has an engineering/production bias. Members are likely to include: Leader of the team and Engineering Director; Production Engineers; R&D staff; Quality/Inspection Managers; and Works Managers. Inputs from sales and finance were carried out as and when required. Detailed prototype drawings are prepared and sent to the customer for comment/approval. At this stage, costings were also prepared from a provisional component list produced by the R&D Department and costed by the Production Department. As has already been stated the process was quite ad hoc and this was especially the case of sales and marketing - *'If the sales force at this stage was enlisted, then a more in-depth market research exercise could have been undertaken'* (Gary Stevens, Dec. 1998).

In summary, there was no framework for new product development unless supported by a customer. A development plan did not exist and the basis upon which new products were developed was a reactive one. The company during the early to mid 1990s did not have a marketing direction or a formal marketing structure. This was all too apparent in the lack of market research activity within the set up and reinforced the lack of awareness towards market forces and market trends which contributed to the onset of decline of the water macerator product range without any warning signs. The basis upon which any new product development project is initially judged is too narrow (return on investment alone). This basis can lead to a stifling effect on the generation of new ideas and ultimately, the successful development of new ideas. Case 5, discussed and analysed in Chapter 8, shows how WEL has begun to change the new product development situation within the organisation and externally. This corresponds to some major structural changes within the organisation.

6.27 CONCLUSION

All firms in the study have a turnover of less than £50 million and employ less than 500 (except in the case of OCL at the time of contact). They all tend to fit the 61% of manufacturing firms that innovate through other means than R&D. Case 1 is SUA as it has a relatively typical customer - supplier relationship in terms of the identified project which is a product innovation that will be outlined and examined in Chapter 7. Case 2 is DFM as the project identified is process orientated which potential has the ability to improve the competitiveness of the firm. So for the discussion chapter later in the thesis I will be able to compare and contrast product and process projects in relation to the theory and in relation to practice from a network perspective. These two cases will also be utilised within the discussion chapter in conjunction with the other three cases identified. Case 3 is OCL and is included because of its decision to access high technology and develop radical new products in the early 1990s producing the TMS project. Case 4 is DDL, which in many ways is similar to that of DFM except that products are produced in house and involve in-house research and development. The project identified in DDL relates to the development of IT systems through incremental developments to aid the organisations market visualisation and product development. Finally, Case 5 is WEL which has its own research and development facilities but has tended to utilise licensing of technology to provide the firm with products that have a competitive advantage over the competition. The project identified links the newly set up innovation project committee with a licensing venture with Philips Electronics Ltd. Therefore, within the discussion chapter the case analysis will be utilised to answer the research propositions and questions set out in Chapter 5.

Each case follows the projects/developments over time and at particular key areas within the project when individual or mass changes occur in the network the network is analysed on the basis of network size, shape, diversity, centrality and openness. This information is then utilised and analysed in relation to the network framework identified in Chapter 4. Taking a closer look at the SIN in relation to the strategic management of technology factors. Ultimately this analysis will be used in the discussion chapter. The cases follow the projects over time and at particular key areas within the project when individual or mass changes occur in the network. The networks are firstly analysed on the basis of network size, shape, diversity, centrality and openness. This information is then utilised and analysed in relation to the SIN network framework. Taking a closer look at the SIN in relation to the strategic management of technology factors. The variables that are examined are summarised in Table 6.12.

Relationship	Committed Communities; Instrumental-Ties (through which mutually rewarding economic exchanges can be operationalised); Affective-Ties (through which satisfying emotional sentiments, such as friendship, can be evoked); Moral-Ties (where code of fairness, social banking and reciprocity, are the main building forces).
Formalisation	Formal recognition (contractual or informal)
Intensity	Is a variable that identifies the strength of link by identifying the frequency of interaction and flow of transaction content.
Reciprocity	Balance and flow over time of transaction content through a given linkage (asymmetric or unilateral) and the flow is symmetric or bilateral.
Multiplexity	Identifies the degree to which two actors are linked by multiple role relations (Tichy 1979).

Table 6.12: Summary of Network Variables

Chapter 7:
INNOVATION: SUA AND DFM

CHAPTER 7

INNOVATION: SUA AND DFM

7.0 INTRODUCTION

In Chapter 6 I gave an overview of all five cases involved in the research. In this chapter SUA and DFM are analysed by means of the SIN framework because of their respective focus on product and process innovation. I start by examining SUA which believes that its future must be based on a strategy of new product development and where possible innovation. The company both in the short term and for the long term must develop products for new customers and new markets. DFM on the other hand takes a different approach to developing new markets and attracting new customers. DFM works closely with customers but has realised that its internal processes especially in relation to marketing are poor. Therefore the company examines and accesses technology that could aid its manufacturing efficiency and effectiveness. Hence process innovation forms the basis of the DFM case. The three remaining cases (OCL, DDL and WEL) are analysed in Chapter 8. The data being supplementary to the two following cases.

7.1 CASE 1: SU AUTOMOTIVE (SUA) DEVELOPMENT

The Traction Control Throttle system for the new Rover 75 mid range car represents SUA's corporate strategy at the end of the 1990s for developing products that are system orientated and which include innovative technologies/products to differentiate them from the competition. The project began in March 1996 with an enquiry from Rover Cars. Rover at the time was planning to introduce new models in 1999, as seen at the Birmingham Motor Show September 1998. These new models required a major upgrade to the engine induction and lubrication systems and improved emission levels. The project was named the R40 KV6 Harrier but will be refereed to as the Harrier Project. Initially, SUA was hoping to produce both the plastic manifold and the throttle body given its experience in producing plastic components for Triumph Motorcycles. However, Rover eventually decided to produce the plastic manifold leaving SUA with the throttle body. This however was not seen as a major problem given that the volume required in the throttle body was 1500 units/week compared to about 100 units/week with the predecessor. There were also other innovations being developed that were of relevance to SUA's business and competitive situation.

Table 7.1 and 7.2 identifies all the network actors during the research. Each individual formal position is stated in Table 7.1 and include: Peter Morris - co-ordinator of many departments such as design, manufacturing, purchasing, logistics and 'coercion'. A key part of his role was as the link with Rover and as he put it he is 'Rover at SUA'; David Chambers worked on the project for 18 months and was part of the purchasing team attached to the project. His role though is quality based and concerns conformance of external suppliers.; Andy Sadler planned the systems, drawings, machines, tooling, gauges, and fixtures drawing on information provided by the Harrier team. He had to meet the capital investment requirements for the project, ensure capacity meets predicted volumes and confirm procurement requirements are met. He draws up operation instruction sheets and technical instruction sheets.; Lynne Mereweather was attached to the Harrier Project for over 18 months through the Logistics department. Her role was broad on the Harrier Project which included logistic co-ordinator, transport manager, and material control responsibility; Richard Insull at the start of the research had been attached to the Harrier Project for 6 months and was part of the purchasing department. He was a senior buyers in charge of purchasing project co-ordination; Roy Cole was originally looking after all commodities for SUA including stepper motors, electronics, bought-out assemblies, springs and presswork. However when Richard Insull joined the team, Roy Cole's main role changed to be associated with special projects, particularly QS 9000 procedures with regards to incoming packages for the Harrier Project.; Ray Oakes scheduled items for dispatch at the point when the agreement with customer and transport is finalised he schedules and dispatch manufactured products; R&D/Engineers had a key role in the innovation of this project ensuring that requirements of the customer were met and developing technologies that would make the product competitive. In Table 7.2 the external actors that play a role during the project are identified. Table 7.2 also identifies the actor they link with at stages during the project and which SIN map they appear on.

Actor	Position/Relationship
Peter Morris	**Project Leader**
David Chambers	**SQA Manager**
Andy Sadler	**Process Engineer**
Lynne Mereweather	**Logistics Co-ordinator**
Richard Insull	**Purchasing Project Co-ordinator**
Roy Cole	**Business Logistics Purchasing**
Ray Oakes	**Dispatch**
R&D/Engineers	**Development**

Table 7.1: SUA - Identified Internal Actors and Positions

External Actor & Type	Template Position	Internal Actors	Map
Rover - Enquiry	Customer	Les Rock	Map 1
Rover	Customer	Peter Morris	Map 2,3,4
Distribution Suppliers - Exel	Supplier	Lynne Mereweather	Map 4
Component Suppliers (Mark Fripp), Gilbert Curry	Knowledge	Richard Insull	Map 4
Gilbert Curry	Supplier	Ray Oakes	Map 4
All Suppliers	Supplier	Roy Cole	Map 2, 3

Table 7.2: SUA - External Relationships by Collected Network Data

7.2 THE PROJECT

The project began in March 1996 when Rover made a formal enquiry. Rover contacted Les Rock at SUA. The enquiry led to an informal Harrier Project network being set up. The network included Peter Morris and Les Rock. Given the enquiry, other internal actors were considered and communicated with to obtain their opinions on the enquiry - can we meet the requirements? how feasible is the enquiry given our current business, technology and skills? The main developments and aims were: to reduce weight; to rationalise casting requirements; to develop a idle speed control valve; to develop the first ever Air Assist Fuel Injection (AAFI); and incorporate Traction Control Device. Each actor had an input into the feasibility of these aims and objectives. Map 1 (Figure 7.1 details in Table 7.3) shows the initial informal network at the stage of the Rover enquiry. The transactions were information-based in order to inform the internal actors and the customer of the needs and requirements of the development. This information transaction assisted in the decision of whether to take the project further.

Network 1 Dimensions	The network
Size	The network at this stage formally and informally included 6 actors. Rover is the external actor and its enquiry dictated the number of internal actors included.
Diversity	Diversity is quite clear in this early network stage. Internally the network includes 3 key departments that could play a role in the development.
Openness	Openness is a key part of the project given SUA is entering into an enquiry that requires a feasibility study. The information/knowledge from Rover must be passed to the key actors so that they can examine the possibilities for the project in relation to their departments. The study opens up the project to the actors in the organisation.
Centrality	The formal hierarchy played an important role in the feasibility study network. Decisions were made by the departmental actors and then the Chairman along with Peter Morris and Rover have to make a decision on whether to go forward. The decision ultimately was in the hands of Les Rock.
Shape	The shape of the network points to the importance of the customer especially in relation to the strong intensity of the relation. All the information back to Peter Morris as the boundary spanner focused back towards Rover. However, the shape shows the importance of including key actors in the decision making process of taking on a project. This shape at this early stage suggests the project was customer/market driven.

Table 7.3: SUA - Network Map 1 Dimensions and Detail

After the feasibility study was agreed by Peter Morris and Les Rock the joint decision was made to formalise the project. This required developing a formal contractual relationship with the customer and formalising the initial network of actors. Project Managers are appointed by the Board and their appointment depends on expertise, competence and knowledge of the customers. Peter Morris was appointed project leader due to his vast experience in Rover projects. The Project Manager is accountable for the project, from setting up and querying the project, to writing the proposal, winning the business and undertaking all the financial details such as presenting the Capital Investment Programme. The formal network of actors was put together by the Project Manager although in some cases the departments nominated a person for the team depending on their workload and time. Actors were chosen based on the requirements of the project development and the customer being dealt with. In this case Rover is the customer and therefore Peter Morris is the choice for team leader as he is the boundary spanner between the customer and SUA. During mid to late 1996 the team was put together starting with engineers and R&D.

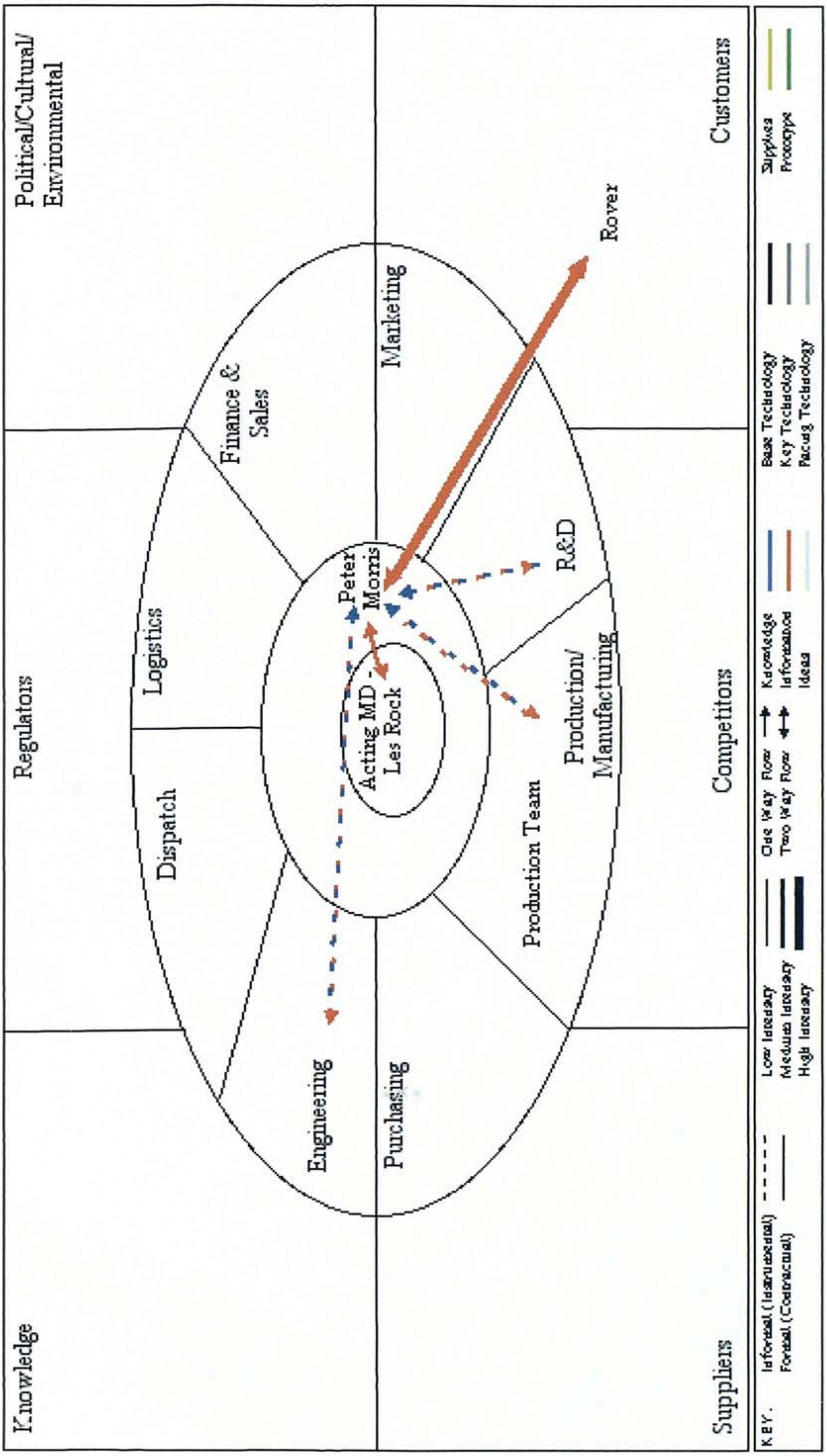


Figure 7.1: SUA Map 1

'Procedures and Practices are laid down in-house but when projects involve the customer then the end customers procedures and practices are followed as a rule' (Peter Morris, Nov., 1998).

The actors enter and leave the project at different phases in its life-cycle on a formal basis. However, the Harrier Project did utilise an informal actor to test new process techniques designed to assist the dispatch and supplies area of the company's value chain. Table 7.4 shows the team positions that would need to be filled and the type of competencies and assets required to fill that position.

Team Position	Requirement
Project Leaders	To run the project given the needs of the customer as well as having a strong understanding of the way the customer runs and operates projects.
Designer	50% of time spent on project undertaking CAD System Design developing the designs for the production phase
Purchasing	A senior buyer whose main job is to examine tooling with suppliers. Currently work is going on producing samples and planning the meeting of times of production.
Conformance	Understanding of quality issues. Currently undertaking capability studies of suppliers by visiting possible suppliers which may fit the desired requirements.
Logistics	Both inward and outward. Inward has strong links with purchasing and outward examining what Rover can cope with regards the reusability of packaging. A source has been nominated for packaging and the development of returnable packaging is underway.
Manufacturing	Machining engineers looking at the machining of the throttle body once the cast is received from Norway. Design is still fluid and there have been problems with movement of the fixings during machining.
Commercial	Very much in charge of the Capital Investment Programme and making sure that this is met.

Table 7.4: SUA - Actor Types for Projects

The actors identified earlier were assigned for different aspects of the project to develop systems, tooling and bring together required technologies and were not full time. They work on other projects hence the earlier reasoning for the creation of informal contacts within the current project at Rover. These contacts may fall within the formal definition within the other projects worked on. The team is therefore not located together. The Board's involvement in the project was both formal and informal over the period of the project. The Board firstly approved the Capital Investment Plan which at the time went to the Echlin Group for finalising and agreement. After this the process is a little less specific however there are mechanisms in place to make the Board aware of the project's progress. Dave Backwell - Site Director has always been provided with an update of minutes every 2 weeks or so. He also has sat in on any of the meetings if he so wishes. The capacity is very much about reporting rather than driving the project. Logistics also provides a link to the Board through Les Rock. All requisition orders go through him to be signed so he's is at the very least aware of expenditure as it happens. And in this way he informally is made aware of the project as it develops.

Map 2 (Figure 7.2 details in Table 7.5) shows the first formal network set up for the Harrier Project. The network at this stage formally included Rover, Peter Morris, Roy Cole, R&D, Engineering, Production and Dispatch. The key actors were Engineering and R&D in the sense that they are formalising the design of the product for the customer and developing technologies for the new product. In this case Rover requested a means to cut fuel emissions through the fuel injection module. In the network transactions are based on information as well as technology. The technologies were key technologies but what could potentially make them innovative and potentially a pacing technology is the way in which they are combined. There was therefore a clear relationship between R&D and Rover in terms of idea generation. Engineering on the other hand generated CAD designs for the traction control throttle that conformed with the Rover engine design.

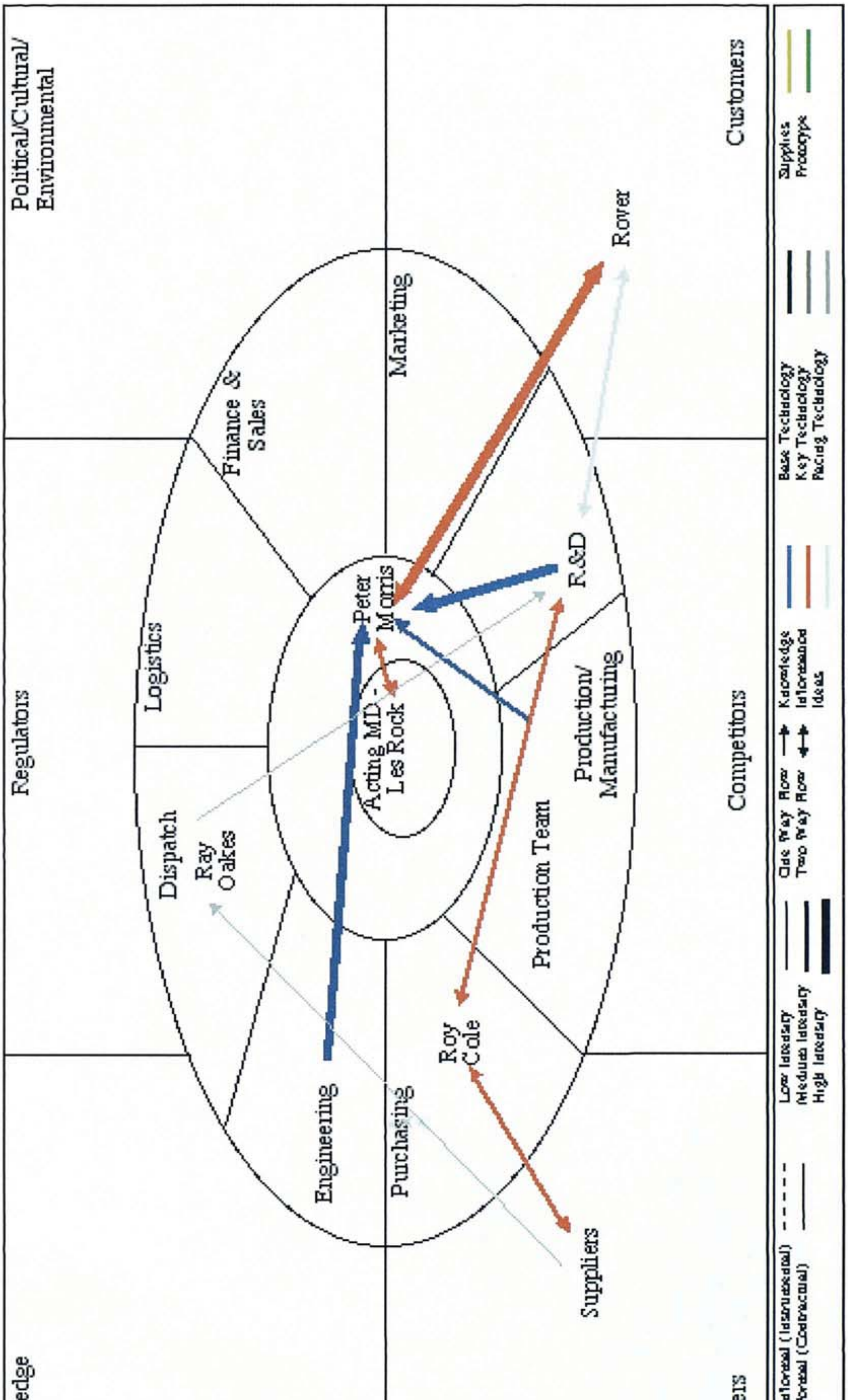


Figure 7.2: SUA Map 2

Network 2 Dimensions	The network
Size	The network size increases at this stage. The size was affected by the development teams requiring supplies, materials and technologies so the network formally included dispatch and purchasing as well as external suppliers.
Diversity	With purchasing and dispatch included the diversity further increased adding to the actors in network 1. This is also added to by the inclusion of suppliers as external actors. The diversity of the network was also increased by the use of internal technologies such as CAD/CAM and competencies from other areas of the organisation.
Openness	The inclusion of purchasing and dispatch did not affect the openness of the project. However, the development of Engineering teams and R&D teams increases the chance of the project awareness and the likely hood that informal actors may provide some input. All actors were part-time on the project and link to a number of other project teams.
Centrality	The formal hierarchy was clearly involved in the network through Peter Morris and Les Rock who attended some meetings. However, in relation to the customer R&D became the focus and shifted the degree of centrality in favour of R&D.
Shape	The shape of the network is similar to the previous network but includes more departments. It continued to be customer/market driven. Although this was balanced with R&D having a direct link to Rover engineers.

Table 7.5: SUA - Network Map 2 Dimensions and Detail

Peter Morris was the boundary spanner throughout the Harrier Project but the R&D department was at this stage providing information. The centrality of the network shifted at this stage to R&D but Peter Morris continued to be the conduit between R&D and Rover. Map 3 (Figure 7.3 details in Table 7.6) shows the formal Harrier Project network after the design and development stage.

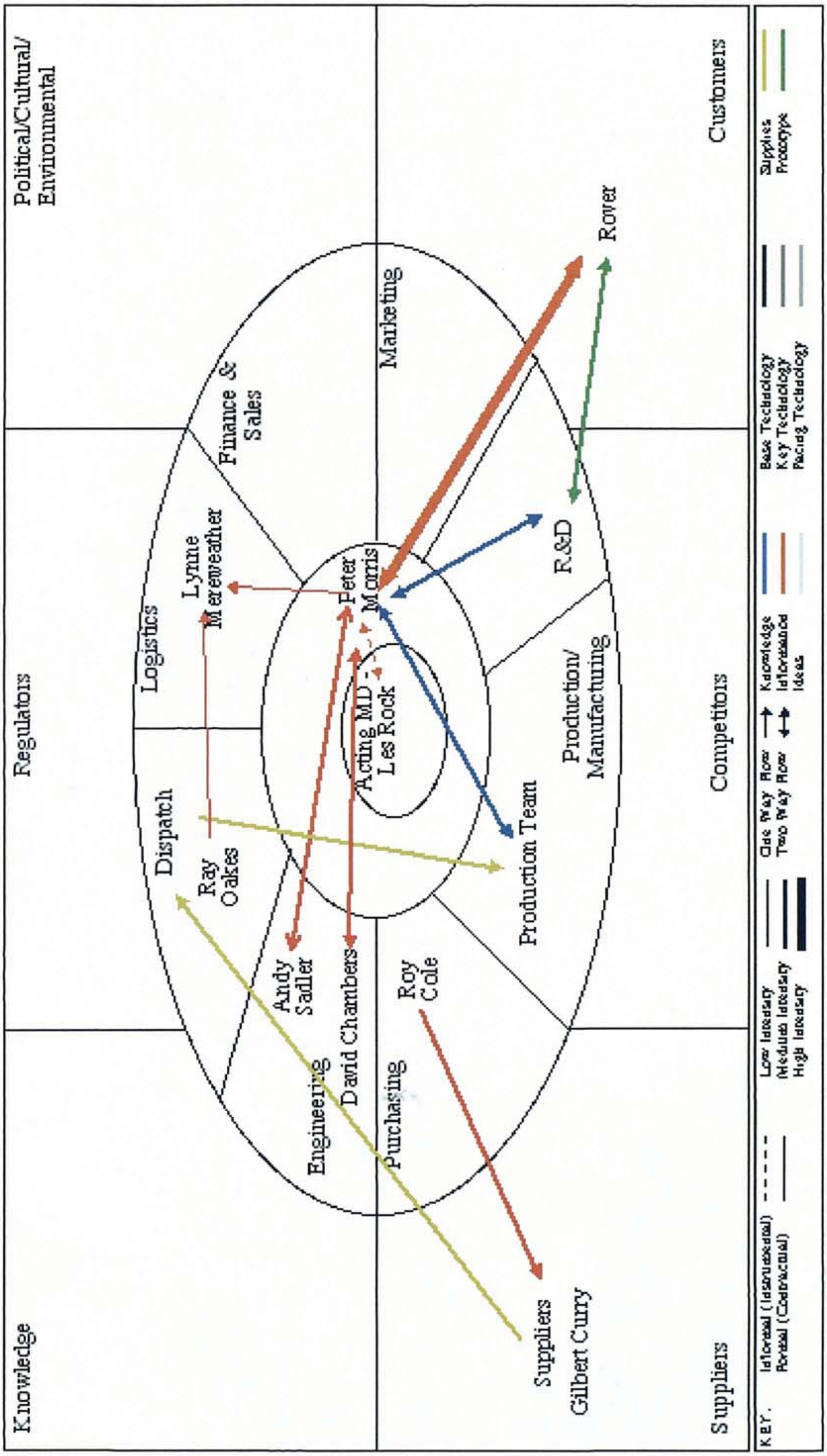


Figure 7.3: SUA Map 3

The network formally included Peter Morris and Les Rock plus Roy Cole (informal); Lynne Mereweather; Andy Sadler; David Chambers; Ray Oakes. Engineering, production and R&D played a major role on a part-time basis. The network continued to be externally focused given the customer requirements were key to how the development was driven. Map 3 (Figure 7.3) shows that the network was mainly information based in terms of transaction content although R&D and production were still accessing information on requirements into tooling and conformance measures. This is highlighted by the knowledge links between these department and Peter Morris. Testing, tooling possibilities and conformance are fed back to Rover so that at Rover they are able to check the project at SUA against the engine being developed.

Network 3 Dimensions	The network
Size	The network size increased at this stage with 11 actors formally involved in the project.
Diversity	Diversity increased further with the inclusion of logistics. As the project got closer and closer to manufacture the requirement of materials and supplies increases.
Openness	Openness did not changed greatly in this network.
Centrality	The centrality of the network reduced during this stage of the network. Les Rock's input and inclusion in the formal network during meetings reduced. He relied on minutes of meetings ect. The reason for this was the change in owner of the company and Les Rock's move towards the formal Chairman's role.
Shape	The shape of the network changed with the inclusion of logistics and increasing value being placed on purchasing and dispatch. The project however was still customer/market driven.

Table 7.6: SUA - Network Map 3 Dimensions and Detail

The links between customer, departments, management, strategic decision-makers, suppliers, information and knowledge inputs, represents the high diversity of actors. The network size is larger than at the feasibility stage with 11 actors - this network is fluid in that Lynne Mereweather, Les Rock and Ray Oakes were at this stage formally related to the development but their input and relevance has varied over the Harrier Project. The centrality of the network at this stage is less clear. The customer has a major say in the development although Peter Morris continues as the boundary spanner between Rover and SUA. The transactions are no longer just information based, the maps shows base technologies (suppliers to dispatch) and knowledge being transferred.

Map 4 (Figure 7.4 details in Table 7.7) illustrates the network at the final stages of the Harrier Project. Lynne Mereweather's role at this stage was very important as the project nears manufacture she was responsible for negotiating the dispatch of the manufactured product to Rover via an external/third party supplier (e.g. Exel). Her links included Rover, external suppliers, Dispatch and Peter Morris. Richard Insull joined the project at this stage to take on Roy Cole's role whilst he worked with suppliers. Lynne Mereweather worked closely at this stage with Ray Oakes to examine and develop the dedicated supplier box. All other actors were still involved to a lesser or greater extent depending on their role.

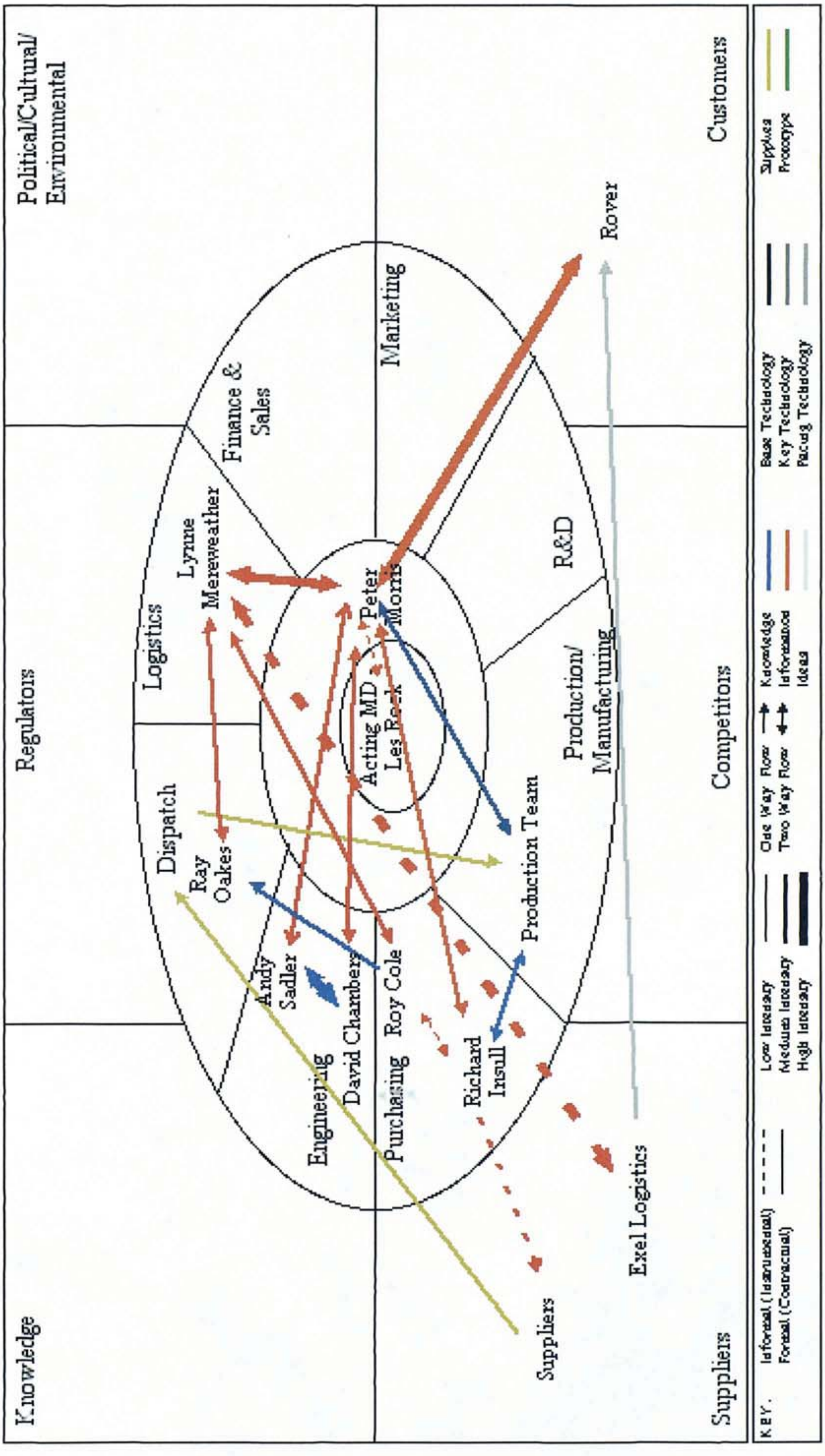


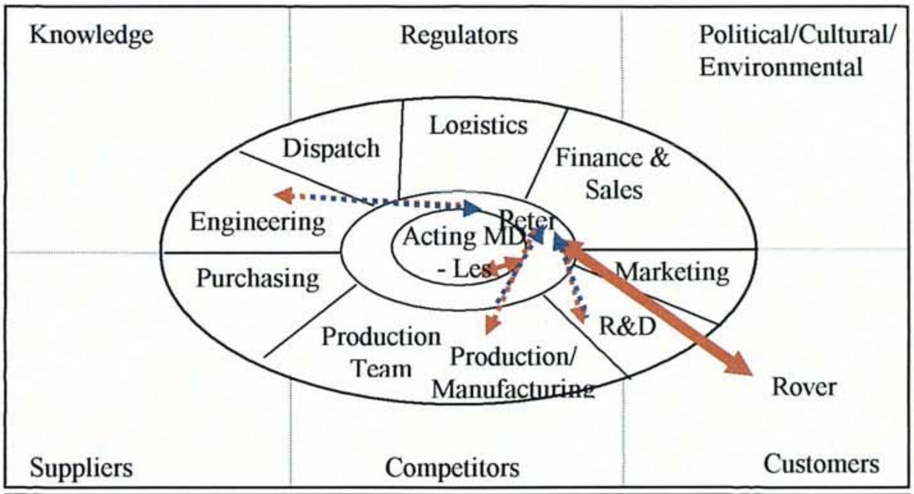
Figure 7.4: SUA Map 4

Network 4 Dimensions	The network
Size	The network size increased again. Although R&D no longer formally played a role. Richard in purchasing joined the network and external logistics came into play.
Diversity	The diversity of the network had not changed although a new supplier joined the network and formal discussions began with Lynne Mereweather and Rover in relation to delivery of product.
Openness	The individual elements of the project near completion and now more than ever the project needed to be open to make sure that they meet the time requirements of the customer including manufacture, delivery ect.
Centrality	The centrality had not changed since network 3 although there are more inputs to Peter Morris. As the project nears manufacture the individual actors began pulling in the same direction requiring Peter Morris to manage this integration. Although the Boards input has been limited at this stage.
Shape	The shape of the network appears busier with more links to Peter Morris and an increase in external suppliers for the reasons outlined. However, the customer/market is still drove the project. This is shown in the discussions between Exel, Rover and Lynne Mereweather to achieve the delivery of the finished project. Rover at this stage 'called the majority of the shots' (Lynne Mereweather)

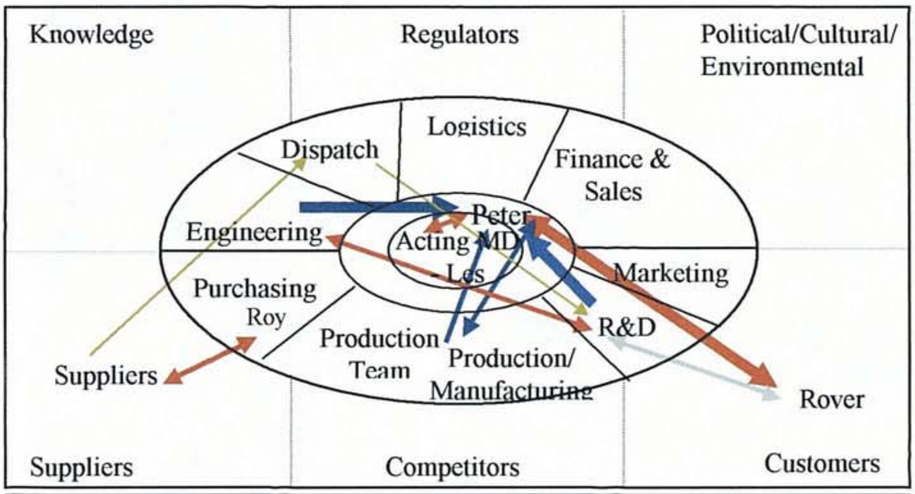
Table 7.7: SUA - Network Map 4 Dimensions and Detail

7.3 NETWORK SUMMARY & FRAMEWORK ANALYSIS

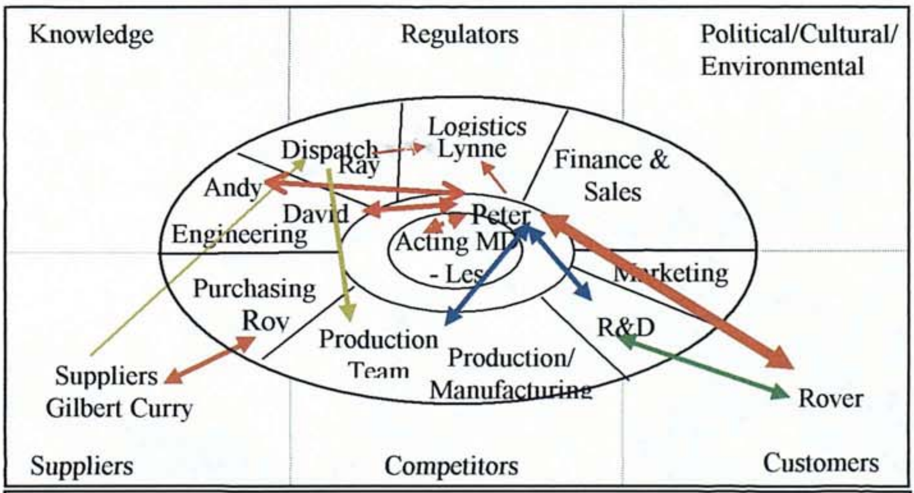
The network maps show that the network changes shape over the period of the Harrier Project. Depending on the stage of the project the network maps show the inclusion or non-inclusion of particular actors to achieve particular requirements of the project. The size and diversity of actors increases during the project. This is no surprise that the innovation process began based around an idea (Map 1 - Figure 7.1) and then a specific project (Maps 2, 3 and 4 - Figures 7.2, 7.3 and 7.4) to develop an innovative product to increase in size and diversity (Tichy et al, 1979). The network maps also show the high level of centrality, in relation to the Board, at the start of the project. However, as the project develops and gets established this centrality shifts from the Board (Maps 1 and 2) to the Project Leader (Maps 3 and 4 - Figures 7.3 and 7.4). The shape of the networks although becoming increasingly dense as the network develops continues throughout to be a customer driven shape. With Peter Morris as the boundary spanner (Tushman & Scanlan, 1981) internally as well as the key link to the customer who set the requirements and in the case of SUA the processes that must be in place to achieve the project. Figure 7.5 summarise the network maps (1-4) of the Harrier Project.



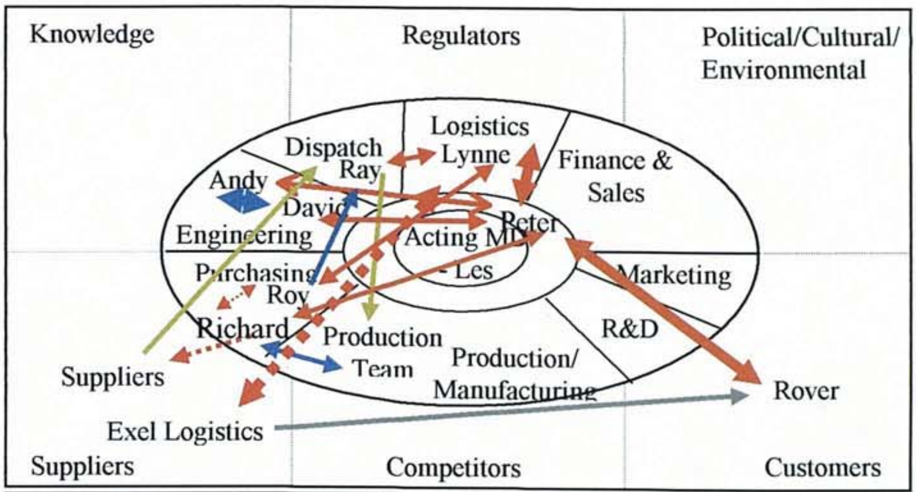
Map 1: Customer Enquiry Network - Informal at this stage. Size - 6 actors; Diversity - internally medium; Centrality - High with Peter as boundary spanner; and Shape - customer/market orientated.



Map 2: Harrier Project Network (Design and Development) - Formalised. Size - 8 actors plus R&D and Production teams; Diversity - internally increased; Openness - High; Centrality - Medium but High with R&D; and Shape - customer orientated



Map 3: Prototyping and Testing Network - Formalised. Size - 11 actors; Diversity - externally increasing with Suppliers and inclusion of logistics; Openness - High; Centrality - High with Peter; and Shape - internal customer/market orientated.



Map 4: Manufacture and Distribution - Formal. Size - 12 actors; Diversity - increased externally; Openness - still High; Centrality - High with Peter; and Shape - customer and supplier orientated.

KEY:			
	Informal (Instrumental)	One Way Flow	Base Technology
	Formal (Contractual)	Two Way Flow	Key Technology
			Pacing Technology
	Low Intensity	Knowledge	
	Medium Intensity	Information	Supplies
	High Intensity	Ideas	Prototype

Figure 7.5: Summary of SUA's Strategic Innovation Networks (SINs)

7.3.1 SUA: Accumulated Technological Competencies & Networks

SUA has a particular process by which it sets up project teams to develop new systems and products outlined earlier in the document. Each individual had particular skills and on that basis were picked by Peter Morris to play a role in the project. The project provided limited competency development. The customer drove the project externally and the basis for the development was orientated around internal competencies. However the development of the Air Assist Fuel Injection (AAFI) for the Harrier Project developed a realisation within SUA that internal competencies could be used to develop products with a competitive advantage.

Actor	Relationship	Transaction Content
Peter Morris	**Project Leader** - instrumental tie	Information - Systems Understanding
	Intensity - High with all actors and externally with Rover	Value - High to drive project, support team/users and bridge team with customer. He is 'Rover at SUA'
David Chambers	**SQA Engineer**	Information - Quality Control
	Intensity - Low with Peter Morris.	Value - High to support quality throughout SUA which then supports individual projects.
Andy Sadler	**Process Engineer**	Information - processes
	Intensity - High with engineers and team.	Value - High in order to ensure engineering processes are designed and in place in order that manufacture may go ahead.
Lynne Mereweather	**Logistics Co-ordinator**	Information and negotiating delivery of parts/product.
	Intensity - Low . Highest with Peter Morris and external actors.	Value - High, as negotiations vital to the finalisation of the project.
Richard Insull	**Purchasing Project Co-ordinator**	Information - supplier knowledge
	Intensity - Medium with Peter Morris	Value - High from a buyers perspective with a strong buyers background.
Roy Cole	**Business Logistics Purchasing**	Information - Suppliers, measures, reports, benchmarking and box control
	Intensity - Medium with Harrier Project as he is involved in many other projects.	Value - High from a supplier development point of view and especially with moves to develop box control the suppliers role will be important.
Ray Oakes	**Dispatch**	Information and planning.
	Intensity - Low to Medium depending on stage of project. Increases when dispatch agreed.	Value - High in scheduling and input on dedicated boxes.
R&D/Engineers	**Development**	Ideas, Knowledge - new product/technology development
	Intensity - High at the first phase of the project. Reduces through the project	Value - High especially in relation to the customer as it provided competitively low emissions on new engines. This also strengthens SUA's value to the customer on a longer term basis.

Table 7.8: SUA - Accumulated Technological Competencies & Network Variables

The Harrier Project used current competencies in throttle bodies and pumps to combine the technologies to create a novel product that would benefit this particular customer (Rover). Peter Morris also saw it as a means of strengthening the link with the customer - *'By providing development skills and novel technologies that benefit the customer means that a longer term relationship may be possible.'* This is important in relation to developing SUA's customer base and attracting new customers. Hence developing internal competencies to utilise current available technologies in a novel and potentially competitive manner can make SUA more attractive and valuable to new customers. This is especially likely in relation to the R&D team that utilised current internal competencies to develop a new technology (AAFI) that cut fuel emissions. The internal links are high however the majority of actors have limited external links and therefore provide limited opportunity to develop competencies. The company has tended to access competencies through customers (Table 7.8).

7.3.2 SUA: Internal Strategic Cohesion & Networks

This factor is a key element in the strategic management of SUA. A very open environment supports internal strategic cohesion in SUA. Management and shop floor break at 10 am for a bacon sandwich and is a key part of the SUA culture. The teams are formally set up but the environment on my visits was quite informal. Everyone has a particular role to play and are expected to follow the formal in-house project processes. *'Providing these are achieved then the project runs as planned......except for the unexpected'* (Peter Morris, Nov. 1998). The team process is common place in SUA and stems from the original link as business unit of Rover. Map 1 (Figure 7.1) shows the importance of the link between customer, Peter Morris and the Board in deciding on a particular project in terms of the feasibility, cost and value to SUA. However, once this feasibility study has been completed and agreed as part of the corporate strategic plan and the project manager decided on then as Map 3 (Figure 7.3) shows the Board has little input.

Actor	Relationship	Transaction Content	Others
Project Team	Reciprocity - Bilateral between team	Activity/Project Support	Diversity - Formalised diversity through project set ups.
	Multiplexity - High due to different functions working together	Information/Knowledge	Shape - shows diversity through a web of links across the organisation.
			Centrality - team centrally focused on Peter Morris as boundary spanner with customer.

Table 7.9a: SUA - Internal Strategic Cohesion and Network Variables

Actor	Relationship	Transaction Content	Others
Project Team with Board	Reciprocity - Unilateral although bilateral with logistics.	Information and money if required for new projects.	Diversity - limited but clear link between Peter Morris and Les Rock.
	Multiplexity - Low link with Les Rock		Shape - shows links with centre.
			Centrality - Les Rock has clear influence at early stage.

Table 7.9b: SUA - Internal Strategic Cohesion and Network Variables

The project as with developments in SUA involved a wide variety of actors to achieve the goals of the project. All through the project from formalisation to completion, as seen in Maps 3 and 4 (Figures 7.3 and 7.4), shows that multiplexity is high (Tables 7.9a and 7.9b) across departments. Production, R&D, engineering all play a role in the project but marketing does not. Marketing generally plays a limited role in new product development as the company has tended to rely on existing customers such as Rover rather than attract new customers. The marketing element of the organisation, as part of the drive to be more innovative and competitive based on products rather than costs, has seen a drive to be more innovative in-house. With the identification of markets and industry developments the company has developed new inventions and systems that are expected to be competitive and attract new customers that may replace Rover. The introduction and greater relationship with marketing in-house is beginning to provide the benefits expected for higher internal cohesion and relationships between key departments. It should also be noted here that with the open-plan offices and the culture that is in place at SUA, there is high multiplexity - providing many informal multiple role relations through affective ties.

7.3.3 SUA: Organisational Specialisms & Networks

The key part of SUA organisational specialism is the development of project teams that are specific to product systems and customers. It means that teams are organised into specialisms such as Oil Pumps and Rover Oil Pumps. There's a Rover Oil Pump Project Manager because within SUA a particular individuals knowledge of a customer's practices and procedures indicates their project management position. The development of project teams is embedded in the formal process of the organisation with Peter Morris calling himself 'Rover at SUA' or 'SUA at Rover'.

Actor	Relationship	Transaction Content	Others
Project Team link with Customer	Formalisation - High through Peter Morris	Information - and Support	Shape - network spans the organisation. Customer orientated.
	Intensity - High		Diversity - high throughout the project to meet requirements and needs of customer.

Table 7.10: SUA - Organisational Specialisms & Network Variables

The customer is a key part of the network from start to finish and leads to the project and networks being customer/market driven. Each individual is a specialist in their area so each is bringing particular project skills to the network to meet the customers needs and requirements. These needs are filtered through Peter Morris during the project as the boundary spanner. Communication within the organisation is fostered through the formal links but more importantly through the open plan office between departments and managers. Therefore daily informal discussions are common which adds to the formal discussions. In this way geographic boundaries within the organisation are removed thus keeping the intensity of the relationship relatively high (Table 7.10).

7.3.4 SUA: External Orientation & Networks

Other than the strong ties with the customers there has been limited effort on the company's part to develop external linkages. There are however certain employees on the ground staff that have taken part in groups and training courses. One of the R&D laboratory members sits on a forum for environmental issues. This as yet has not provided any significant benefits for SUA as it is seen as more of an interest for the employee. What has proved beneficial are the training sessions that some of the manufacturing staff have attended. The sessions are seen as offering the employees a higher level of training. As the Logistics Director stated

> *'....the benefit is to improve the 'company brains' and 'internal learning'. We have developed training groups among the staff to learn from individual employees that have been on the training course and developed some 'cohesive competencies'* (Les Rock, May 1998).

The ties with companies are used on a social basis to get groups of managers together. Football matches are used to meet other managers and SUA see this as an opportunity to pick up information within the customers organisation and any potential developments which are on the horizon that may have a bearing on SUA in the future.

In terms of the project there is not a high external orientation. The main orientation is with Rover and the strategic supplier base of parts for producing the Harrier. These are very formal links. What is clear throughout the project period is that even at the enquiry stage (Map 1 - Figure 7.1) by Rover the customer is the key driver of the project development. Customer requirements play a strong part in the decisions made by the project leader in deciding on the actors involved. Hence external influences affect the actors and relationships on the project network. Map 4 (Figure 7.4) shows a further external development which is standard practice as projects near the manufacturing stage and near delivery to the customer. This is the negotiations with Exel for supplying the product to Rover and involves discussions with both the potential supplier as well as the customer, and internal departments such as dispatch. These external links are mainly between internal management and possible suppliers as all material and customer negotiations involve Lynne Mereweather or Peter Morris. Multiplexity between customer/supplier and SUA tends to be low, multiplexity is higher internally between the team. These are summarised in Table 7.11. The supplier relationships in the majority of cases have been long term many since SUA was part of Rover. Trust and understanding has been developed so there is seen to be a limited need to increase the diversity of suppliers.

Actor	Relationship	Transaction Content	Others
Peter Morris	Rover Multiplexity - Low Reciprocity - Bilateral	Information - advice	Diversity - one customer.
Lynne Mereweather	Rover logistics negotiation and now Exel Multiplexity - Low Reciprocity - Bilateral	Information: Requirements for delivery form Rover via Exel	Diversity low although Exel has been used before and is trusted.
Roy Cole/ Richard Insull	Material Suppliers Multiplexity - Medium Reciprocity - Bilateral	Commercial and technical Cost and timing	Diversity of suppliers is limited as the company has a set of suppliers it tends to use from project to project.

Table 7.11: SUA - External Orientation and Network Variables

The organisation in general has begun to develop its external orientation and not simply at the management level. Since environmental regulations prevented SUA producing the carburettor, SUA has involved itself in regulation issues at the car manufacturing level by gathering legislative data from the UK government as well as European Parliament. This also provides the company with information on the early stages of legislative development. This means the company can be more proactive in terms of its environmental impact and hence why it set up its own Component Environmental Impact Assessment as discussed earlier. External training is computer skills has increased in-house at the level of engineering and production with skilled employees training courses to learn how to use, and programme new process technologies. Their training is then applied were possible in-house with the trained individual formally training other employees. The company's external orientation is aimed at making the organisation more aware of its environment and allowing it to be pro-active rather than re-active as it was with the carburettor. It has also made management more aware of competitors by visiting trade shows and conferences at least once a year to communicate and gather information on the competition.

7.3.5 SUA: Management Skills & Networks

Very few formal management tools are used at SUA such as forecasting and technology mapping).

> *'No! At this level few management tools are used at all. Project planning and procedural and process guides are invaluable however'* (Peter Morris, Nov. 1998).

However, an important element of the SUA project team and network process is the setting up of teams to suit particular customers. The management of this is very important for SUA and hence as touched upon earlier different project managers/leaders have particular roles depending on the customer and are picked given their knowledge of the customer. Each project network is built around the customer and the particular project leader with the relevant knowledge of the customer. Peter Morris had instrumental and affective ties with individuals and groups throughout the organisation and importantly a high level of multiple role relations in order to provide Peter Morris with a diverse network of relationships that can be pulled on to develop the required network for a customer project/development. The higher the multiplexity the stronger the network in terms of complementary assets as well as required competencies. High multiplexity aided Peter Morris's management of the project (Table 7.12).

Actor	Relationship	Transaction Content
Peter Morris	Instrumental & affective ties	Information - Project
	Multiplexity - High with team individuals and Board.	To formalise project to meet Rover needs and fit SUA's requirements.
	Formalisation - High	Value - High
Lynne Mereweather	Instrumental & affective ties	Information - Manage requirements of Rover/Customer and SUA.
	Multiplexity - High with buyer/logistics side of the team and Medium tie with Board for project.	Manage and formalise the logistics of the project
	Formalisation - High	Value - High

Table 7.12: SUA - Management Skills & Network Variables

Maps 1 and 2 (Figures 7.1 and 7.2) show the importance of Peter Morris as the link to Rover and the fact that he is the boundary spanner of information from and to the customer and internal actors. Lynne Mereweather also has a very important role in the management of the final stages of the project in terms of the logistics of the manufactured product. It is her role to negotiate, with Peter Morris's input, with Rover and possible logistic suppliers. SUA tends to use a logistics supplier such as Exel and the same was the case in this instance, the company had used Exel many times and trusts them. The management of this phase of the project involves Lynne Mereweather networking closely with Dispatch, external suppliers, Rover and Peter Morris (see Map 4 - Figure 7.4). The objective is to negotiate a contract with the likes of Exel that meets the requirements of Rover and SUA.

Core team meetings (CTM) throughout the project have been held fortnightly to raise issues and discuss the current development of the project. Peter Morris certainly felt that communication was a key element in the running of the project from his point of view at all levels. These meetings tend to be report driven and this can also be said of the use of Project Management Tools and Project Time Lines which *'.... 'are not made best use of.' and tend to be used in a 'reactive' rather than 'proactive' way'* (Peter Morris, Nov. 1998)

7.4 SUA SUMMARY

The network process in SUA is quite well defined even though it is not formalised. Networks that develop around customer enquiries and then around projects to develop new products relate closely to the processes and procedures that are formalised in-house to undertake a project. A number of examples of this are raised in the case such as Peter Morris as 'Rover at SUA' and the defined actors types required for projects as seen in Table 7.4. The company's competencies fit the current customer base that SUA has and this has been developed with customers in mind. However, SUA now sees the future as uncertain and the reliance on Rover and current customers could prove a poor strategy regarding sales and future development. The Harrier Project was one of the first to utilise internal competencies to develop new technology. However, to continue to develop new technologies the company has to examine the external knowledge bases either through customers or as in the case of the PUREX system through external inventors. This could assist in providing the company with competencies and knowledge as well as complementary assets that offer some competitive advantage over the competition. SUA can no longer compete on cost alone especially with the parent company (DANA) expecting increasing returns. New technology and innovation can aid this as the AAFI proves. The understanding and use of internal competencies has been encouraged and potential benefits are being seen through increasing internal cohesion at the strategic level through feasibility procedures (Map 1 - Figure 7.1). SUA has shown in recent history that internalising competencies both for competitive and strategic reasons is possible with its developments and usage of plastics in throttle body manufacture and utilising this understanding and knowledge in the new innovations briefly discussed in the case. External orientation has been limited at SUA and has tended to be reactive rather than proactive especially in the case of emission legislation and general environmental legislation. The company has tended to focus its external orientation on customers which has ultimately tied the company to those customers. This is not necessarily a bad thing providing there is a balance with industry and market as well as technological awareness and understanding of its own. However, this was limited at SUA in the mid 1990s. SUA has tended in the past to view itself as a supplier to the automotive industry rather than as a manufacturer of automotive products for the automotive industry meaning it has supplied what has been required rather than attempting to be competitive and develop the products in its own right. Development has been externally orientated towards customers but driven by the customers with little examination of what is occurring in the wider context of technology and the industry as a whole.

7.5 CASE 2: DENNIS FERRANTI METERS (DFM) INTRODUCTION

Unlike SUA, the following company has taken a different approach to innovation. The manufacturing business is run like a jobbing shop, reliant on contracts that can vary dramatically. *'The company produces no specific product line or range.'* (Personnel Manager, Oct. 1999). The products manufactured have tended to change around every six months varying from contract to contract. There has been no marketing which from the point of view of new product development and innovation, it is argued, is not positive (Coombs, 1987). During the summer of 1999 Paul Diver was appointed as Marketing & Sales Director in an attempt to orientate the business to customer requirements. Until 1996 the organisation and specifically the Board had a limited view of competitiveness and innovatory potential. Although the project outlined in the following case was born from a shift in organisation strategy to develop processes, efficiency changes and the utilisation of information technology rather than product development. An important element to this change was the examination of manufacturing and production processes as well as operational processes and then to transfer and mirror many of these via a new information technology system.

7.6 RE-PROCESSING THE ORGANISATION

As pointed out in Chapter 6 the company needed to bring internal hardware and software systems into the year 2000 and in doing so improve the efficiency and effectiveness of processes. In doing so new procedures to meet and support the new systems were needed to help ensure the future of the company. The Board did not want to replace the existing system without firstly examining ways in which manufacturing processes could be made more efficient and easier to control and also to remove the strength of the materials division from the running of the old system. One aim being to make all functions equal and supportive of the business and not one individual function to have overall control. Table 7.13 identifies all the internal network actors that were interviewed and Table 7.14 summarises the external actors utilised and their links to internal actors.

Actor	Position/Relationship
Bill McKenna	**Project Leader** - instrumental tie
Gareth Williams	**Project Manager**
Angela Williams	**Process Mapper**
Hugh Sillitoe	**Data Systems Engineer**
Module Champions	**Department Managers**
Shaun Wrigglesworth	**Process Planning Engineer** - replaced Hugh Sillitoe
Dave Jones	**IT Engineer**

Table 7.13: DFM - Identified Internal Actors and Positions

External Actor & Type	Template Position	Internal Actors	Map
Module Champions	Knowledge	Angela Williams	Map 3
Module Champions	Knowledge	Bill McKenna	Map 4
David Riley - DataWorks	Supplier/Knowledge	Bill McKenna	Map 3 - 4
IBM - Hardware Representative	Knowledge	Gareth Williams	Map 2
CIMTEL	Supplier	Hugh Sillitoe	Map 2 - 4
CIMTEL	Supplier	Shaun Wrigglesworth	Map 5
SAGE	Supplier of Software	Dave & Dean	Map 5
Technopoly	Supplier	Dave & Dean	Map 5

Table 7.14: DFM - External Relationships by Collected Network Data

Map 1 (Figure 7.6 details in Table 7.15) identifies the network in place at this early stage of the potential project. The key protagonists are Gareth Williams, Ken Chandler with Hugh Sillitoe providing information on the current IT systems.

Network 1 Dimensions	The network
Size	**The formal team at this early stage was small with 3 actors. Although informally other Board members were made aware of the groups ideas.**
Diversity	**The diversity of the network was limited. The initial team examined the problems of the current IT system**
Openness	**Openness in terms of the organisation was very limited although the small network was open with the Board and the key decision makers within the Board through Ken Chandler.**
Centrality	**The network was centrally guided with the inclusion of the Board in the decision to go with the project. It was Hugh Sillitoe and Gareth Williams' job to sell the project to the Board and make them see its value.**
Shape	**Shape was limited with the small number of actors at this stage. The shape focused on the current IT technology in-house and the decision makers.**

Table 7.15: DFM - Network Map 1 Dimensions and Detail

DFM was attempting to introduce a comprehensive, integrated computer system. The General Manager, Ken Chandler, launched the project in April 1996. Gareth Williams was appointed

Project Manager and team members identified by Ken Chandler and Gareth Williams. Further informal additions included Ken Galliford, Peter Bently, Adrian Foster, Jason Selby, Michael Cooper and Bill Cooper all Board members. The objectives of the project were:

- to protect the good business practices
- enable data capture and interpretation and validation of data
- enable capacity planning and scheduling
- to provide dynamic material status tracking
- to expose processing delays
- to avoid returning to a system which cannot develop with the company in particular areas (Legacy System).
- to develop an enterprise wide materials planning system
- enable a cellular manufacturing environment
- enable faster response to internal quality problems
- enable performance monitoring

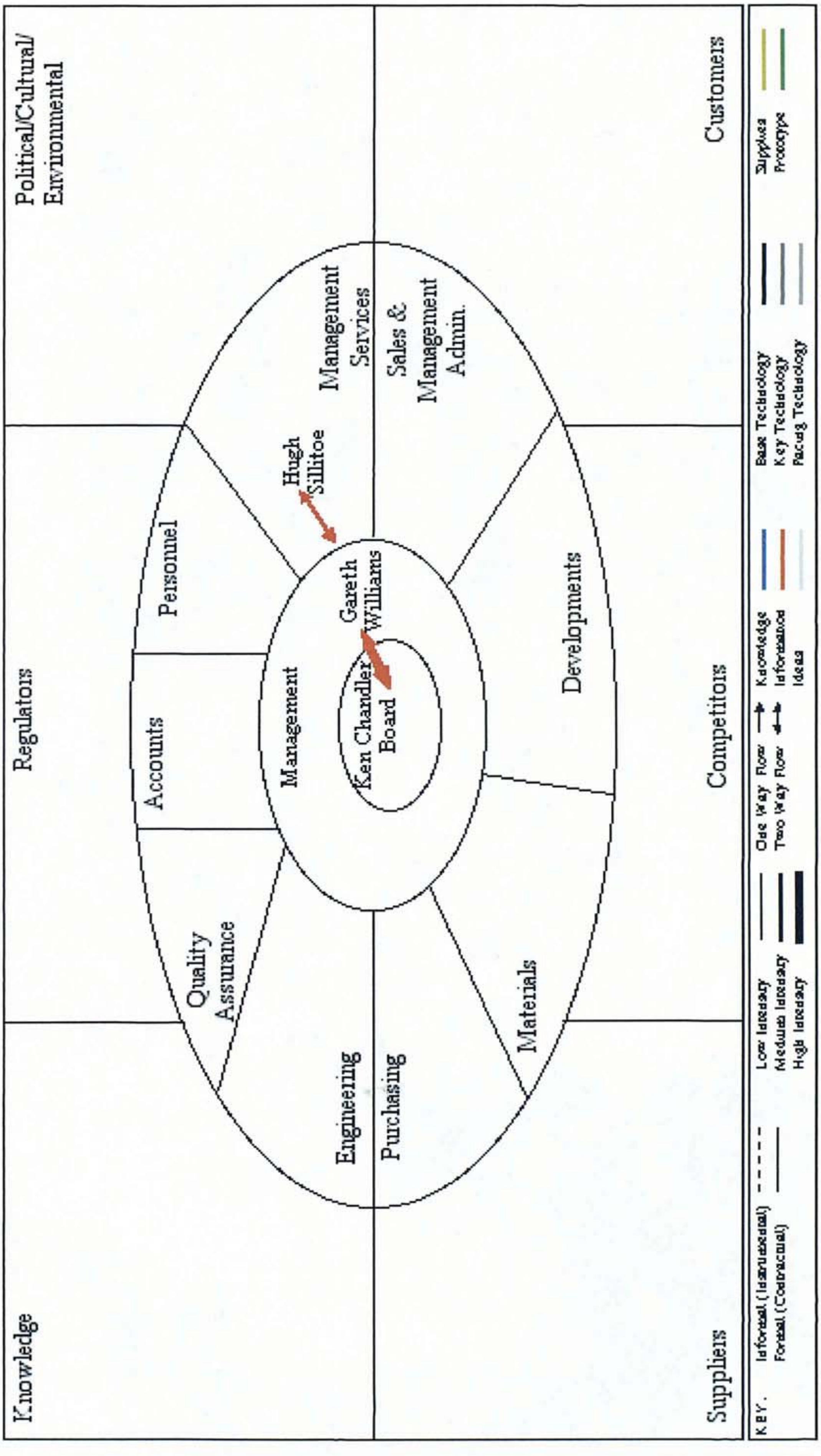


Figure 7.6: DFM Map 1

Once the decision was made by the Board to implement the project then the need to develop a formal team was required. A decision was made to recruit externally due to limited internal competencies. The company recruited a mature graduate with a background in computers to assess the possibility of introducing a system that integrated a variety of activities including materials requirement planning (MRP). It was considered desirable to integrate information on the shopfloor piece-work scheme, planning, estimating and the monitoring of work in progress. Because the project was at an early stage there was scope for integrating new technologies into the manufacturing process. Re-evaluation of manufacturing activities was seen to be key and has helped in identifying areas in which there is potential for collaboration and networking with suppliers of manufacturing software and hardware. So the team at the start of the project consisted of Gareth Williams, Bill McKenna (hired for his knowledge of IT systems), and Hugh Sillitoe (whose role it was to examine the IT/Software marketplace in terms of the requirements of the project).

Network 2 Dimensions	The network
Size	The team expanded by one with the hiring of Bill McKenna. The size of the network also expanded externally. Total number of formally identified actors was 8.
Diversity	The diversity of the network was limited at this stage although that is not surprising. Bill McKenna at this stage was brought in to examine the current systems across the organisation and to assist in the examination of the supplier market for potential solution. External diversity has therefore increased.
Openness	Internally the openness was limited with almost no formal involvement of departments and individuals throughout the organisation.
Centrality	Centrality was very high with Ken Chandler monitoring and being fully aware of developments. In fact before any decisions and spending he had to authorise them. The external orientation took a greater focus.
Shape	The shape did not directly changed in house but changed externally with the examination of vendors and the advice taken from external actors. The shape at this stage suggests that the project was likely to be more technology and supplier driven.

Table 7.16: DFM - Network Map 2 Dimensions and Detail

Map 2 (Figure 7.7 details in Table 7.16) shows the network focused on the IT/Software suppliers with Gareth Williams as the boundary spanner for the project. The project is focused at this stage around the Board and Gareth Williams. Some advice was taken from an IBM hardware representative to undertake a vendor rating exercise to narrow the field of possible suppliers of systems to meet the aim of the project.

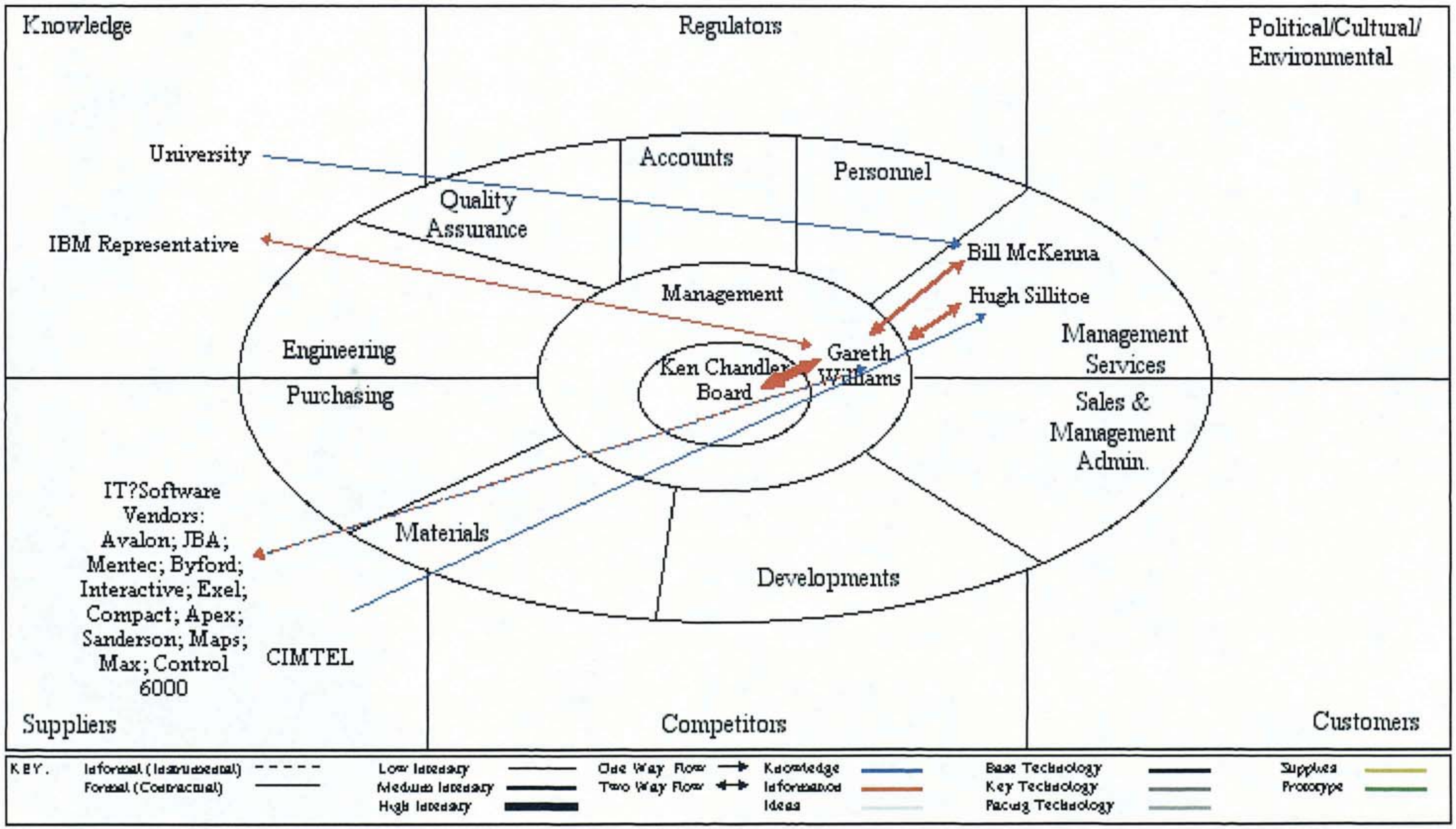


Figure 7.7: DFM Map 2

The representative provided advice on what to look for in relation to types of vendors. This advice was taken and the management team in DFM set up the project to move through a number of phases. The phases are outlined in the Table 7.17.

DATE	PHASE	ACTION
Spring '96	Selection Phase 1	Test Market
Summer/Autumn '96		Researching Needs
Winter '96/'97	Selection Phase 2	Matching Vendors with DFM 11 Vendors were discarded.
Spring '97	Selection Phase 3	6 Shortlisted Vendors Examined for Functional Capability
March '97		2 Vendors couldn't be split. Two demonstrations were organised.
Summer '97		Preferred Vendor/s Identified & Declared.
Autumn '97		Final Budget Submitted, Approved & Orders Placed
Winter '97/'98		Implementation Commenced
May '98	Phase 4	Accounts Go Live

Table 7.17: DFM - Project Development

The market was examined by investigating vendors through a questionnaire. The questionnaire included 101 questions each vendor was expected to complete. On completion the answers were examined to see how they fitted with the objectives of the project and the requirements expected from the vendor. At this stage in Jan 1997 12 potential vendors (Avalon; JBA; Mentec; Byford; Interactive; Exel; Compact; Apex; Sanderson; Maps; Max; and Control 6000) 6 were discarded. At this stage each of the 6 were examined in terms of what system they could provide given the functionality requirements in DFM's departments. It was decided during this process that one particular vendor - Sanderson could be 'a safe bet' but this potentially would have left the company in a similar situation. It also became clear that DFM itself would require some restructuring and modularising of departments. The vendor, DataWorks (who bought-out Interactive), was selected to supply software and hardware including new PCs, and 3 new servers (see Financial Status sheet for costs). Ultimately these 3 servers replaced the two servers running the old system (386 16MB Servers). Certainly, there were no illusions about the system - '*.....along with most of the other actors working on or around the system the initial aim is to be 'No worse off!'*' (Gareth Williams, April 1998). It was expected that for some time much of the system would not be fully utilised. This was as much to do with reducing the intensity and complexity of the change but also because the system was expected to develop over time.

STATUS MARCH '97
Realisation Of Scale of Project - Potential Benefits Not Fully Realised
Planning Vendor Criteria
Need To Secure Understanding Through The Company
Relevance To Functions Must Be Clearly Defined & Communicated
Acquiring Knowledge & Understanding Of Selection Process
Process Mapping Seen As Key To Clarify Key Business & Functional Requirements As Well As Areas Of Critical Success.

STATUS FEB. '98
Implementation Approach & Structure Formulated
Existing Processes Mapped & Implementation Support Being Provided
Train The Trainer Approach Applied
David Riley - DataWorks Project Manager In Once A Week To Assist.
Bill McKenna - Co-ordinating Activity Of Elected Module Champions

ACTION FEB. '98
Complete Formal Education of Module Champions
Test System - Preparation for Go-Live
Incorporate Easy Changes
Refine, Expand, Develop Full Potential Of System

ACTION APRIL-MAY '98 Put Back to MAY-JUNE '98
Last week in May get data for accounts in shape
Go Live with accounts for one month

Table 7.18: DFM - Project Status

Bill McKenna (Project Leader) 'was hired to drive the project' (Gareth Williams, April 1998) and to act as the link between all key players involved. He also dealt closely with the supplier (David Riley - DataWorks) of the system both at the training level as well as at the system level. He was involved in all meetings regarding the systems and along with Gareth Williams as the key link back to the Board. Bill McKenna's role was viewed as key to the system succeeding. Originally he undertook a quality assurance (QA) on the old system. He took a logical approach to the system that went against the inherited thinking behind the older MRP system. He initially identified the areas in which the old system was deficient. It was this identification that led to the joint decision with Gareth Williams to undertake a process mapping exercise during and on completion of the vendor rating. Map 3 (Figure 7.8 details in Table 7.19) shows the network that was formed on the back of the QA and that would provide the detail to the project and the system to be developed in conjunction with the chosen supplier. The map shows a very different configuration to Map 2 (Figure 7.7).

Network 3 Dimensions	The network
Size	The formal network expanded dramatically in size with the inclusion of module champions and Angela Williams.
Diversity	The diversity of the network at this stage increased. The development of the module champions gave the network links to all departments within the organisation and therefore a link to their knowledge.
Openness	The openness throughout the organisation increased by the link to the module champions and their knowledge of processes.
Centrality	At this stage with the decision on the vendor centrality was important in the decision by Ken Chandler to agree the cash on the basis of what DataWorks can offer and how that fitted the Boards view of the project.
Shape	The network covered the whole organisation in terms of links but was being driven through Bill McKenna and the vendor and its products and what could be done with the software.

Table 7.19: DFM - Network Map 3 Dimensions and Detail

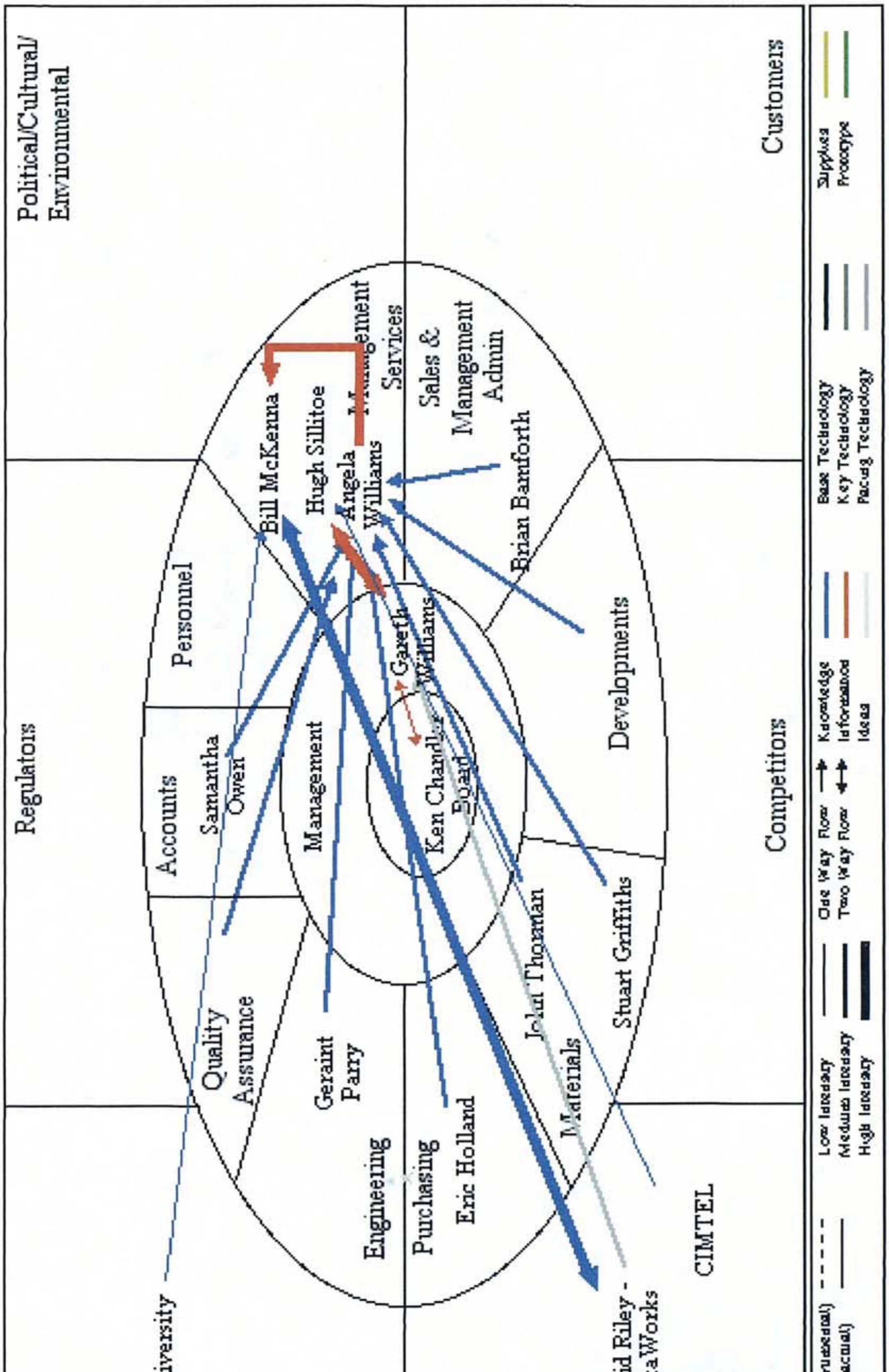


Figure 7.8: DFM Map 3

The focus internally and externally shifted from the Board and Gareth Williams to Bill McKenna who became the boundary spanner between the company project and the supplier and consultant developer David Riley. During this period of the project Map 3 (Figure 7.8) identifies that the majority of transactions are based on accessing knowledge about different departments through the module champions as well as external knowledge from David Riley. This formed the basis for the process improvements and identified the areas where process improvements could be made by way of increasing current efficiency throughout the manufacturing, production, materials, finance departments. It also aided the identification of future developments and provided the basis for the development of the company wide computer system giving the basis for the vendor rating and what was required from the vendor and software supplier. Angela Williams was hired to undertake the process mapping whilst Bill McKenna began working with the vendor.

Map 3 (Figure 7.8) shows the relationship between Bill McKenna and David Riley from the supplier company which developed around an appreciation of IT knowledge and according to Bill McKenna was an 'intense relationship in terms of communication and action'. He visited the company monthly. The team set up an issue form reporting system. These forms contained issues that would have arisen in testing or problems/difficulties that users encountered. David Riley collected these forms and then either answered them immediately or took them away for consideration and to plan and solve solutions. At this point the company also began purchasing the Hardware and Software solutions to begin the process of development. This step in the project did not pass through normal purchasing channels but through Gareth Williams with Ken Chandler signing off purchase requisitions.

Bill McKenna and Gareth Williams realised that the creation of module champions would be vital as the complexity of the change was such that elements/functions within the organisation were likely to conflict given the shift in operational emphasis. The module champions role within the project was therefore important on a number of levels - *'The development of the module champions is key to the project getting off the ground'* (Gareth Williams, April 1998). Each module champion was key to individual departments within the organisation and responsible for their areas of the project and championing the changes that the project brought to their department.

January 1998 saw the formulation and implementation of the approach and structure that was to be introduced. The mapping of individual processes within DFM and implementing support for the integrated computer system orientated the approach. Each module champion was linked formally with Angela Williams (Information Technology Process Mapper). Her role was to document and map the processes by working directly with each champion to identify those processes within their work functions. Angela Williams was also formally linked to Bill McKenna. She began by identifying how for instance the Materials function is sub-divided into operational functions (i.e. Materials was broken down into Materials Management, Production Control, Material Control and Purchasing). The module champions identified the processes and Angela Williams mapped them (typical of business process re-engineering). It should be noted that it was never the intention to alter individual processes. The only element of re-engineering came in the way of removing processes that were unnecessary. The process maps provided the basis for the systems in the individual functions. More importantly however, they highlighted areas where functions overlapped and procedures were unnecessary. Hence processes were tightened up and improved.

Module Champion	Role
Geraint Parry - Document Control	**Responsible for pulling together the process map for producing the bill of materials.**
John Thorman - Scheduling	**To identify the key and sub processes that underlie scheduling within the company.**
Stuart Griffiths - Master Production Scheduler	**To get used to the system but more importantly assisting in identifying information needs from the point of view of scheduling and its impact on other areas in the company.**
Meirion Parry - Store Manager	**Comparing the old system with the new and identifying problems, difficulties as well as advantages.**
Dave Jones and Dean Williams (Pay-Roll Module Champions	**Both these module champions roles crossed a number of boundaries within the organisation given they are two of the main IT specialists in-house in terms of data conversion and IT network set ups. Unlike the others they've had strong external links with suppliers of IT software to provide module solutions utilising conferences to access solutions.**

Table 7.20: DFM - Summary of Module Champions

On completion of the process mapping phase Angela Williams left DFM June 1998. During her role at DFM she worked closely with a number of key individuals - module champions. Not all the module champions identified were at the time of the research involved in the project. However, those that were interviewed were: Geraint Parry -

Document Control; John Thorman - Scheduling; Stuart Griffiths - Master Production Scheduler; Meirion Parry - Store Manager; and Dave Jones and Dean Williams -Pay-Roll Module Champions. Their roles are summarised in the following Table 7.20.

All module champions agreed that the project started from the basis of being 'no worse off'. Although few major improvements were made individuals did point out particular value in their areas. The feeling was that stock and inventory management was now more professional especially in the way suppliers are dealt with.

The mapping provided the basis for Bill McKenna and David Riley to convert the processes into a system/software solution that link to key areas of the organisation. The conversion from a manual to a software solution can and often is quite difficult but in the manufacturing process the majority of processes are document based to trigger the next stage. So the system would use documentation to model the processes. In doing this those module champions had to: re-learn the document development process; learn how to generally use the new system; and understand its value in terms of what it could do for them in relation to the complete manufacturing/production process. Therefore training was an important element of the project.

The company set up a training room in-house which provided access to all the systems in development. The training in-house was part of the package and therefore cost-effective relative to sending individuals out of the office on training courses. Also the benefit was that the individuals can test the new systems against the old 'paper' system. Hence they could see the benefits and offer opinions, thoughts and ideas for improvements.

> *'The company has developed a training schedule around what we call a training matrix which is designed in such a way as to allow all those to be trained to share knowledge with the next level on the training matrix'* (Bill McKenna April 1998).

Training began with the module champions. It began with those that had their function included in the first phase of the system going live. Those included were: the accounts department and shop floor. An initial live test of accounts occurred in the summer of 1998.

All module champions were intended to train their subordinates. Map 4 (Figure 7.9 details in Table 7.21) shows that first level of this matrix with each module champion formally linked to both Bill McKenna and David Riley. During the training period Bill McKenna provided general information to the module champions and their processes were turned into system/software solutions. Both actors sat down with each module champion to run through the processes from contract negotiations to final manufacture focusing on the whole process whilst showing the relevance of their module to that process. Map 4 (Figure 7.9) highlights the network that evolved in relation to the training process.

Network 4 Dimensions	The network
Size	The size of the network at this stage had not changed.
Diversity	The diversity of the network continued as in the previous network but we now see a change in relationship between Vendor, Bill McKenna and Module Champions. With the Vendor providing software solutions whilst Bill McKenna trains and passes on information on how to use the systems.
Openness	Openness was greater at this stage with not just knowledge/process gathering but training as well. Openness increased through the Module Champions training their departments individuals.
Centrality	Centrality at this stage was less necessary in the sense of strategic direction. Solutions now developed and the Board through Gareth Williams simply wanted to see results.
Shape	The shape had not changed but the relationships changed. The IT/Software developed and included the training and understanding of the individuals and the organisation.

Table 7.21: DFM - Network Map 4 Dimensions and Detail

Map 4 (Figure 7.9) shows the relationships between Angela Williams and the module champions changing to links with Bill McKenna. Turning the process maps into solutions meant that the relationship of the module champions with the team shifted to Bill McKenna who at this stage provides the module champions with details of the development and what was to be achieved with the processes in relation to the IT solutions. The point being to '*.......ease the module champions into the training that would be required*' (Bill McKenna, April 1998)

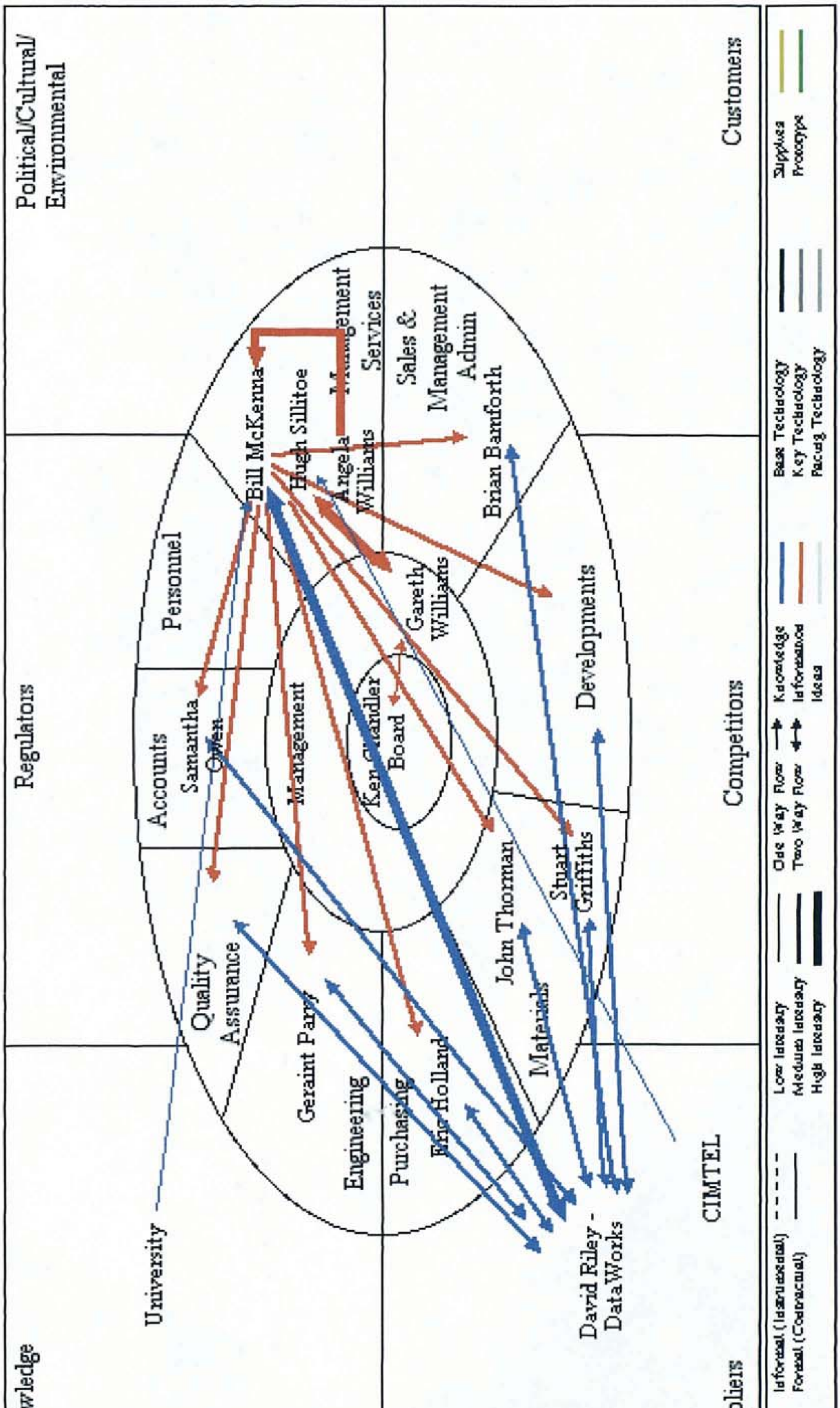


Figure 7.9: DFM Map 4

Software was implemented to match business functions which focused on open systems to simulate internal systems. As Hugh Sillitoe stated *'...my view of the new system is one of interactivity and a major step forward from planning on paper'*.

CIMTEL software was introduced in 1997. It was to assist in solving the year 2000 compliant problem that Hugh Sillitoe was hired. His first job was to assess the CIMTEL software and to investigate possible solutions to the year 2000 problem and if the software could integrate with other software packages around the company. Early indications were that integration was going to be difficult due to variations in ODBC compliance and potential cost. The solution was that information and critical data could pass to the new DataWorks Avante system (software InfoFlow 8.0 now known as Avante 8.3.8). This did however require a restructuring of the data. During May - June 1998 he began transferring data between systems. Hugh Sillitoe never met the deadline and the data up to November 1998 was not fully transferred. Hugh Sillitoe left DFM in the summer and was replaced by Shaun Wrigglesworth - *'a very methodical man ....whose role has been made quite difficult by the link between the two systems being complicated by the changes in both the system owners'* (Gareth Williams, Nov. 1998)

Nearly five months of conversion work was lost due to Hugh Sillitoe's decision to leave DFM, with much of the conversion work unfinished. The two companies supplying the data systems (DataWork - Avante and CIMTEL) provided the support. As pointed out by Shaun Wrigglesworth, *'I have had to come in and learn the current systems and what was executed by Hugh and in doing so understand, plan and programme to rectify the problems of conversion.'* The change at CIMTEL generated concerns as it was likely that the key personnel dealt with through Hugh Sillitoe may have gone. Implications at this time were unclear. Both DataWorks and CIMTEL changed hands a number of times during 1998 which did effect the pace of the support from both. *'It is quite possible that this support for linking the two systems may be removed by one or both companies due to the change.'* (Shaun Wrigglesworth, Nov. 1998). The Avante to CIMTEL conversion was completed, however the data conversion back slowed the process down. Shaun Wrigglesworth, Dave Jones and Dean Williams from IT could have undertaken the conversion themselves but this would have required extra training in the underlying fields and programming of the two packages - *'Unfortunately we had no time'*. This shows that Hugh Sillitoe's knowledge was critical in terms of achieving specific time frames. However, although time was lost '*....it is very unlikely that the conversion could have been achieved by now*' (Dave Jones, Nov. 1998).

Bill McKenna left DFM before any of the systems went live. His leaving however, did have implications for the project. Gareth Williams stated that he had a great deal of knowledge of the project and the individual modules and it was hoped that he would stay until Christmas 1998 to complete the research required. However, he declined to renew his contract and joined DataWorks - '*Bill was poached by DataWorks.......the lure of a company car and more money was too strong*' (Gareth Williams, Nov. 1998).

However, DFM and Gareth Williams were not bitter about this and saw this as a common source of recruiting in the IT industry. The advantage of Bill McKenna's departure was that module champions could no longer rely on him to solve all their problems and needs. Therefore he was no longer a way out for managers according to Graham. However, in the same vain it has left a situation where work still needs to be done and the champions have to do it but getting them to do it has proved very difficult. He did continue to have an informal link with Gareth Williams. He prior to my meeting with Gareth Williams on Nov. 13th 1998 had picked up information and queries regarding the project with the possibility of providing insights and answers to current problems, however he would not be available to implement any of the answers that might arise. The link with DataWorks - Avante change becoming very informal through Bill McKenna and David Riley no longer had a formal link with DFM.

> '*It was always the intention of Ferranti to avoid too much support from the supplier as they didn't want to be led by DataWorks it was always about doing it ourselves*' (Gareth Williams, Nov. 1998).

Network 5 Dimensions	The network
Size	The network size reduced but not significantly.
Diversity	The diversity of the network was very similar to previous networks although there was changes to external suppliers and internal actors. Bill McKenna left but continued to have an informal link to Gareth Williams to provide limited assistance with project development.
Openness	The module champions continued to run their parts of the project with accounts having gone live but still work to be done on completing other departments as well as further development in accounts/finance.
Centrality	The centrality of the project reduced further. At this stage there was an announcement by the Board to Gareth Williams that further money was unavailable. So Gareth Williams needed to find ways of managing the final stages of other projects.
Shape	The shape had stayed almost the same with software and suppliers still influencing the development of the project. Hence, Dave Jones and Dean Williams's links to accounts software and payroll software.

Table 7.22: DFM - Network Map 5 Dimensions and Detail

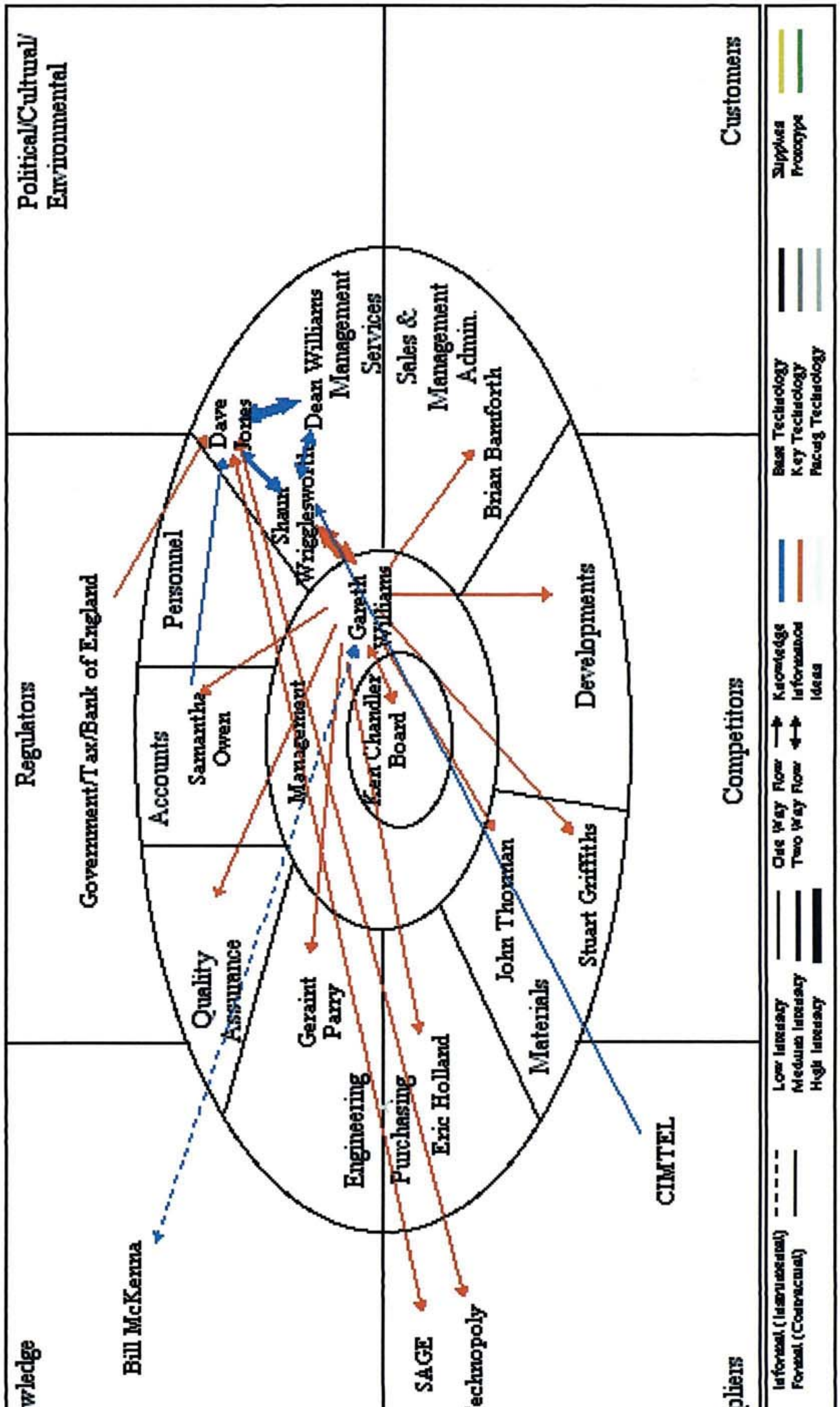


Figure 7.10: DFM Map 5

Map 5 (Figure 7.10 details in Table 7.22) highlights this change in key personnel around the project. With Hugh Sillitoe, Angela Williams and Bill McKenna leaving, the shape of the network changed dramatically. The focus and attention of the module champions being placed on Gareth Williams. The intensity of this relationship with each module champion lessened given time constraints and limited knowledge relative to that of Bill McKenna's. However, Hugh Sillitoe's replacement was seen to aid the speeding up of data conversion which was well behind schedule and Gareth Williams's role changed to one of convincing each module champion that they can achieve their module's goals although it may take a little longer. However, certain areas of the project did go live although not to schedule and the benefits are beginning to be seen. The two module champions for the payroll module have examined a number of software packages by visiting trade shows and whilst at a Payroll Show - IPD Conference in Harrogate they examined specific payroll software none of which directly met the needs and extreme variables of DFM's pay needs. However, a software package by SAGE provided the possibility for meeting the needs of DFM providing a front end could be produced to allow it to run with the new system. The right front end could provide entry fields and requirements that met the payroll structure of the organisation and use the SAGE software as a back end to take the calculations and implement the pay requirements whilst also continuing to produce the usual reports. A company was identified to produce a front end for the SAGE software package. Technopoly was asked to examine the possibility of developing a front end via Microsoft Access that has integrity and compliance with the Avante system. Confirmation was received Nov. 13th however, the decision was still needed whether to go with that or another possibility - although there wasn't one. Hence, Map 5 (Figure 7.10) shows the link between Dave Jones and the regulatory bodies regarding financial implications to pay and conditions as well as software providers. Normally they would go directly to the Financial Director however, information was slow to appear so Dave Jones went direct using the governments web-site to obtain up to date regulations and tax codes.

The company viewed the £25,000 spent on services from DataWorks as small. There was at this stage no money available for changes to be made to the system. It must be said that the IT department in DFM could have worked on such matters but they are highly time constrained with developing the payroll system; managing the IT for the company; and data conversion allowed no time to spend on aiding the likes of the Finance Manager.

Accounts went live but not in accordance with the project time frames and plans. The plan was adjusted by a month to provide time to complete data conversions from Avante system to CIMTEL system. The accounts was to go live at the beginning of May but given the lag in the data conversion this was reset to the beginning of June because there was a shut down for one week at the end of May. This provided an opportunity for the data conversion to be done without impacting on the usual running of the company wide system as for that week it was not in use. Also the sales part of the accounting module was not ready to go live and this is still the case as of Nov. 1998. This led to on going discussions between Gareth Williams and the Finance manager. The Finance manager was expecting the sales part of the module to be achieved by Gareth Williams, however with the loss of Bill McKenna this is unlikely. A conflict of interests developed with Gareth Williams hoping that Finance will achieve what is required especially given that they in the last two months have increased their staff size to double. Without Bill McKenna to guide and assist that the confidence with finance to do this was lacking -*'Finance lack the confidence to get it done'* (Gareth Williams, Nov. 1998).

Date identified	Issue	By Whom
Jul. 98	Work order partial completion of module awaiting testing	DW, KG
Jul. 98	Purchase order item lines for duplication.	KDG
Jul. 98	System displays, validates and selects only 7 charc. of an 8 char. field. Allows negative stock to be issued.	KDG, DJR
Aug. 98	Purchase 4002 allows for every duplication and no alert message displayed	MP, DJR
Jul. 98	Options under 'Lot number doesn't include Oty. or bin as 'F3' at 'bin' does.	MP
Sept 98	Picklist is not updated as stocks are used before actual picking of orders.	DJR

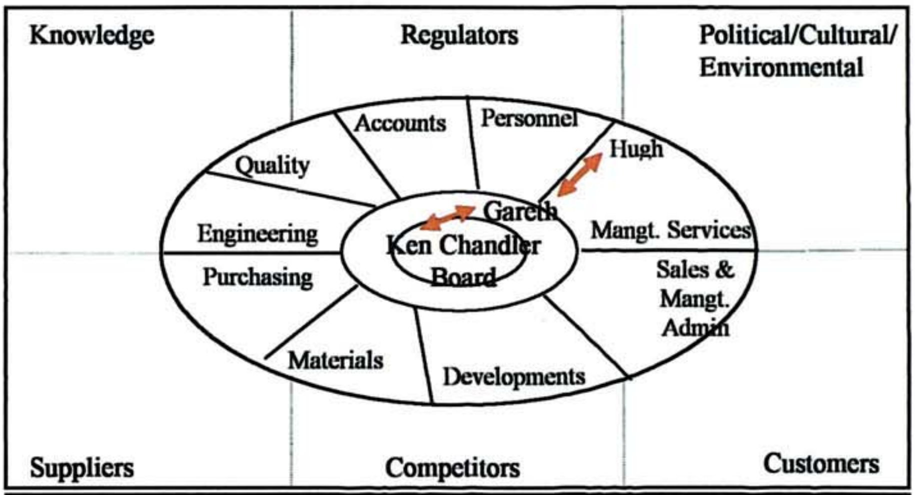
Table 7.23: DFM - Open Issues List

Running the accounts live against the old MRP system allowed the team to monitor and compare the new against the old. "6-7 high priority issues" were identified and the initial benefits were also seen. The benefits were observed in the reporting part of the module with reports being obtainable instantly and new reports being possible. The high priority issues produced a list known as the Open Issues list that identified the requirements to be met to get the system into shape. The main issues are seen in Table 7.23. An issue that was raised by all users not only in accounts but also in stock control was that *'certain parts of the system are slow due to the number of windows you have to access to achieve the job.'* (Gareth Williams, Nov. 1998) A prime example being the booking in of stock/inventory *'...which used to take a* *few seconds, where as given the number of windows you have to move through, can now take up to 2-3 minutes.* ' (M Parry, Nov. 1998) This may be viewed as a drawback but the advantage is a wider one and that is the integration of such inputting with other areas of the organisation such as stock control with the shop floor, materials and manufacturing.

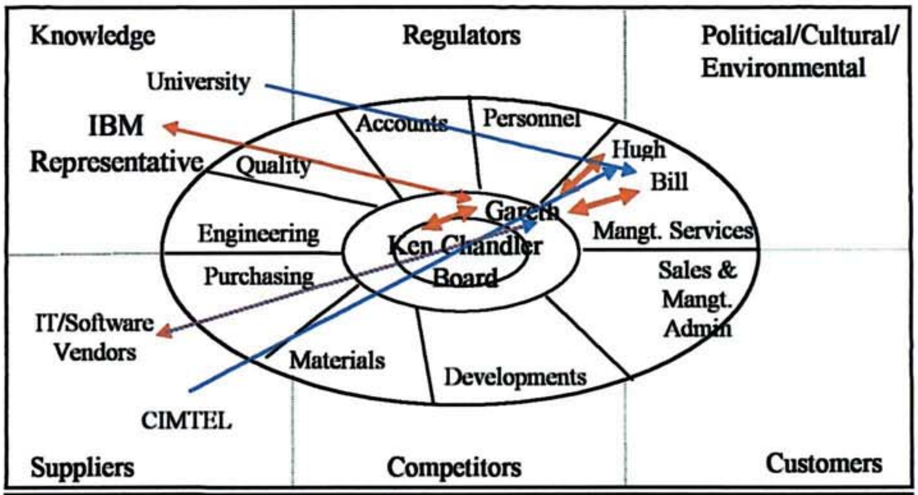
It is important to note the reaction of the Board to the testing and the event of the accounts going live for the month of June. The Board's reaction was very favourable in terms of the project's development and success and led to the team being taken out for dinner and drinks to celebrate the initial success of the comparisons of new against old.

7.7 DFM: NETWORK SUMMARY & FRAMEWORK ANALYSIS

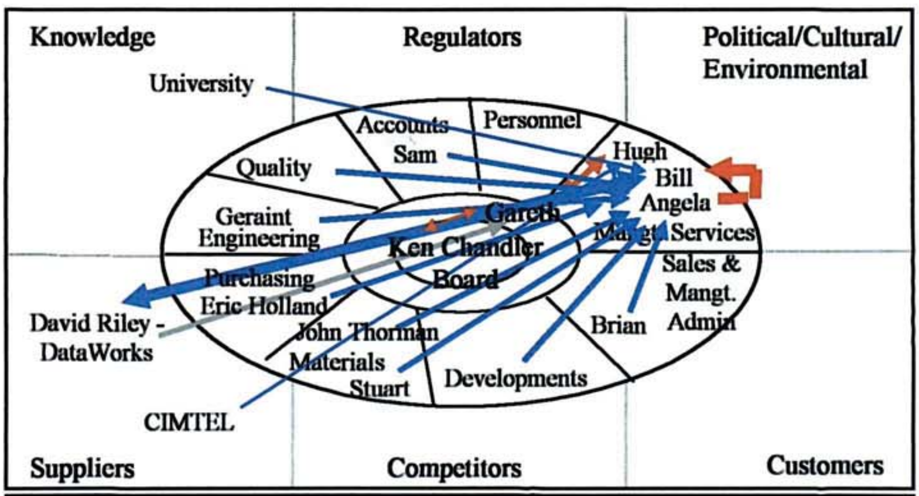
Maps 1,2,3,4 & 5 (Figures 7.6, 7.7, 7.8, 7.9 and 7.10) show that the network changes shape over the period of the project. The DFM project began with questions relating to the internal IT systems and MRP systems assisting manufacturing within the firms. Depending on the stage of the project the network maps show the inclusion or non-inclusion of particular actors to achieve particular requirements of the project although a core team is always in place. The maps show the size and diversity of actors progressively increasing during the project. In this case the increase in diversity is particularly internal as the network develops. External diversity is high during the vendor-rating period in order for the company to examine different types of suppliers. The network maps show the high level of centrality in relation to the Board. Centrality is highlighted at the start of the project by the relationship between Gareth Williams and Ken Chandler. As the project develops and is established the centrality of the relationship increases between the Board and Gareth Williams in relation to the transaction from idea (Map 1 - Figure 7.6) developments to information (Maps 3, 4 and 5 - Figures 7.8, 7.9 and 7.10). The shape of the networks although becoming increasingly dense as the network develops internally. The shape indicates and supports the fact that the network was internally driven firstly via the Board and then through Bill McKenna given his particular competencies. Bill McKenna is the boundary spanner to the suppliers. This role changes once the mapping process by Angela Williams (Map 3 - Figure 7.8) is complete when Bill McKenna then becomes the key link to the module champions and therefore spans the internal boundaries (Map 4 - Figure 7.9). Having examined the network I will now use the framework developed in Chapter 4 to examine variables that impact on the strategic management of the project/technology and the network and explains why particular networks, actors and groups are used and connected to. Figure 7.11 summarise the network maps (1-5) of the DFM IT/internal process project.



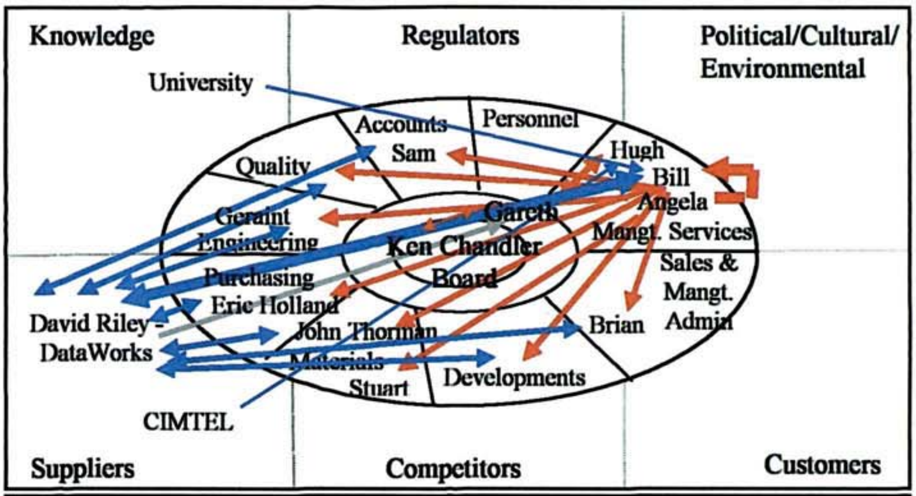
Map 1: Internal Enquiry Network - Informal at this stage. Size - 3 actors; Diversity - low; Openness - High between individuals; Centrality - High with Ken; and Shape - internally orientated.



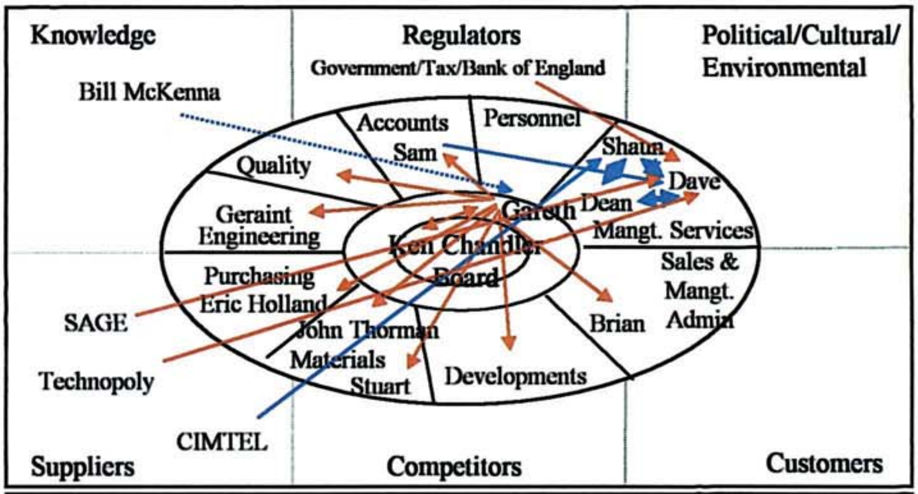
Map 2: Vendor Rating Network - Formal Internally and Informal Externally. Size - 8 actors; Diversity - High externally; Openness - High between individuals; Centrality - High with Ken & Gareth; and Shape - externally or supplier orientated.



Map 3: Q&A - Business Process Network - Formal Internally and Externally. Size - 17 actors; Diversity - High internally; Openness - High between individuals; Centrality - High with Ken & Gareth; and Shape - internally orientated. Knowledge a key factor.



Map 4: Training/Learning Network - Highly Formalised. Size - 17 formal actors with dept actors also involved; Diversity - High internally; Openness - High; Centrality - High with Gareth; and Shape - information and knowledge sharing very internal.



Map 5: Gone Live Network - Highly Formalised. Size - 18 actors; Diversity - High internally and increasing with suppliers; Openness - High between individuals; Centrality - High with Gareth; and Shape - same but intensity has reduced

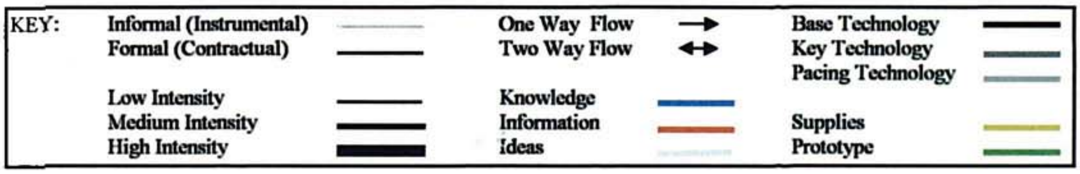


Figure 7.11: Summary of DFM's Strategic Innovation Networks (SINs)

7.7.1 DFM: Accumulated Technological Competencies & Networks

At the outset of the project it was quickly realised that the company did not have the in-house skills to make an informed decision on a new manufacturing IT system. Competence development has come in the development of the module champions to understand, learn and use an IT system and be part of its development now and into the future of the company. To do this the company recruited Bill McKenna as the project leader to support the team and the users and begin the learning process within the company. Hugh Sillitoe was also hired to meet a problem that the old to new system would have and that was transferring existing data to the new system being developed. There was no one in the company that could do the job as it was highly skilled and required a full-time approach. Many of the competencies involved around the project have been bought in (apart from the management of the project) but key to this is the module champions many of whom have worked at DFM for many years. Their knowledge of the job processes were vital to the project.

Actor	Relationship	Transaction Content
Bill McKenna	**Project Leader** - instrumental tie	Information - Systems Understanding
	Intensity - High with all actors	Value - High to drive project, support team/users and bridge team with supplier.
Gareth Williams	**Project Manager**	Information - Project Management
	Intensity - High with Bill McKenna and Hugh Sillitoe.	Value - High to develop a new system culture.
Angela Williams	**Process Mapper**	Information - processes
	Intensity - High with module champions and Bill McKenna	Value - High production of process maps forms the basis of the new system and how it will likely develop. Also should lead to major improvements.
Hugh Sillitoe	**Data Systems Engineer**	Information plus software to bridge legacy data systems.
	Intensity - Medium. Highest with Gareth Williams	Value - High, as conversion of data is critical to new system.
Module Champions	**Department Managers**	Manufacturing Process Knowledge of different areas
	Intensity - Medium with Angela Williams at the start. This changed when Bill McKenna and David Riley began working with the champions to train them.	Value - High to develop and allow the translation of process to IT system as well as improving efficiency.
Shaun Wrigglesworth	**Process Planning Engineer** - replaced Hugh Sillitoe	Data Analyst expertise. Information plus software to bridge legacy data systems.
	Intensity - Medium. with Gareth Williams as well as Dave Jones and Dean Williams.	Value - High to get systems working in harmony.

Table 7.24: DFM - Accumulated Technological Competencies & Network Variables

After areas of the project went live in mid 1998, the team radically changed with Bill McKenna, Hugh Sillitoe and Angela Williams leaving. This left holes in the competencies surrounding the project. Bill McKenna leaving left the project without a project leader and meant that knowledge of individual projects went with him. However, Bill McKenna has provided some limited input to the project including advice. More importantly Hugh Sillitoe had left an incomplete data conversion so Shaun Wrigglesworth was brought in with his Data Analyst and System expertise. Table 7.24 summarises each actors accumulated competency variables.

7.7.2 DFM: Internal Strategic Cohesion & Networks

The factor is a key element in the strategic management of DFM. The project was given the go ahead by the Board because of its strategic implications at a competitive level. As the managing complexity and change literature states it is important in making any risky changes to operations that might affect employees to enlist their support as early as possibly and provide them with a sense of driving individual elements of the change. This has been a key area in the project by way of bilateral discussions and developing the role of the module champions. The inclusion of the module champions role is seen in the maps (Maps 3 & 4 - Figures 7.8 and 7.9). This gave the network a very high level of multiplexity (summarised in Table 7.25a and 7.25b) which ultimately supported the learning and training of all employees in departments and functions without requiring Bill McKenna or some one to be the trainer of all individuals. The champions have mapped their own processes, examined the key points of that process and its impact on other areas of the organisation as well as the impact from other functions on itself. In undertaking this process the module champions have come to realise the flaws in the original way things were done and that improvements can be made and that the new system will provide further benefits never before possible. It is important to note that the module champions perceive, and rightly so, that with the old system they could not have achieved what will become possible with the new system in place. Keeping the module champions on side was 'a tough job' for Bill McKenna as they required a lot of pushing.

Actor	Relationship	Transaction Content	Others
System Team	Reciprocity - Bilateral between team	Activity Support	Diversity - developed into a high diversity with module champions.
	Multiplexity - High	Information/Know How	Shape - network creates a spiders web.
			Centrality - High through Bill McKenna and Graham.

Table 7.25a: DFM - Internal Strategic Cohesion and Network Variables

Actor	Relationship	Transaction Content	Others
System Team with Board	Reciprocity - Bilateral	Information	Diversity - Graham is the key link so diversity is not high.
	Multiplexity - Medium to Low		Shape - indicates inclusion of organisation, through Graham linking to the Board.
			Centrality - High with Board influencing decision on project and link with Graham.

Table 7.25b: DFM - Internal Strategic Cohesion and Network Variables

Strong support came from the Board and progress meetings with the Board were held during each planned phase of the project. If anything unplanned arises then the Board is also consulted. The maps show a recurring relationship through each stage of the networks evolution and that was the link between Gareth Williams and Ken Chandler. The multiplexity in relation to the whole network was low to medium in relation to Ken Chandler but with Gareth Williams acting as the boundary spanner. He was in a position to keep the Board and Ken Chandler well informed. Information was available at every development of the project and kept the Board aware of developments. Such information would and could have allowed them to scrap the project at any time if it was felt that success and the aims/objectives could not be met. This Board awareness was also further strengthened by the fact that any financial decisions on the project could not go-ahead without the Boards approval. This is not unusual but it gives high centrality to the project (Table 7.25b) and gives the Board control if the project leaves the strategic direction of the organisation.

7.7.3 DFM: Organisational Specialisms & Networks

During the period of Map 1 (Figure 7.6) the network diversity was small and therefore the relationship with the formal company hierarchy was low. The project is 'not the normal business of the company'. The network was pulled together especially for the purpose of achieving the desired goals of the project. The network was highly formalised and its intensity is high given its impact on the whole organisation. Maps 3 and 4 (Figures 7.8 and 7.9) show the Management Services teams link with the organisation and how the project in embedded in the organisation. Angela Williams and then Bill McKenna were the key links with the individual departments through the module champions but their knowledge was critical to the developments and ultimately the success of the project. Therefore, the project is seen as highly embedded in the organisation (Maps 3 & 4 - Figures 7.8 and 7.9). This embeddedness is seen both in relation to the high level of multiplexity outlined in the previous factor (internal strategic cohesion) and in the high level of internal diversity of actors involved. Especially in relation to skills, knowledge and understanding developed over the life of the individuals working and operating in the departments (summarised in Table 7.26). The use of module champions embeds the project with the organisation.

Actor	Relationship	Transaction Content	Others
System Team link with Company	Formalisation - High	Information - and Training Knowledge	Shape - The shape suggests the network is embedded in the organisation
	Intensity - High		Diversity - very high with the multiplexity of links through module champions.

Table 7.26: DFM - Organisational Specialisms & Network Variables

The highly formalised relationships were contractual and impacted on the day to day running of the organisation and were therefore intense. The knowledge being extracted and turned into procedures helped develop the IT/Software system relying on explicit knowledge being provided. Communication within the organisation was fostered through the formal links. However, there was limited communication across departmental boundaries within this project and is channelled through Bill McKenna and Gareth Williams rather than being direct. However, departmental communication was developed with open planned offices and daily informal discussions were not uncommon. Geographic boundaries within the organisation do exist which is why Bill McKenna and Gareth Williams were in place during the project to keep communication and the transfer of information high.

7.7.4 DFM: External Orientation & Networks

In general the external orientation of this project was quite limited and this is quite indicative of the organisation generally with no marketing or sales department. During the project the only external link was with the supplier of the system and hardware. The external orientation is however highest during the period when advice was taken from an IBM Rep. Diversity of external actors was high when considering the vendor market and possibilities for a new manufacturing system. Although 11 vendors were talked to and questioned these were very informal links to simply establish a benchmark at first, to avoid returning to a bespoke/legacy system and to gain as much information on possible solutions in order to make an educated decision. The external orientation became more formal when vendors were asked to present their options to the Board. The choice of vendor provided a very formalised agreement with DataWorks and specifically David Riley. In Map 5 (Figure 7.10) it is seen that the external orientation of the network has developed and broadened over time (e.g. the inclusion of a new external actors, namely SAGE as well as Technopoly). Therefore, external orientation was used to supply solutions to project problems or needs when required. The multiple role relations or multiplexity for external orientation is generally low with all internal actors (see Table 7.27). Individual actors during the project defined links with external bodies but there is limited inclusion in those relationships of other internal actors. However, given these links are intended to benefit the system long term then ultimately we will expect the external knowledge and technologies being supplied to touch the whole organisation.

Actor	Relationship	Transaction Content	Others
Gareth Williams	IBM - Hardware vendor Multiplexity - Low Reciprocity - Unilateral in favour of Gareth Williams	Information - advice on vendor ratings	Diversity - High with vendors to provide options.
Bill McKenna	Origin - Link with David Riley through sub-contracting to a supplier of information systems. Multiplexity - Low Reciprocity - Bilateral	Information: Requirements from Bill McKenna and answers from David Riley	
Bill McKenna	Origin - Link with University through studying for an MSc Multiplexity - Low Reciprocity - Unilateral in favour of Bill McKenna	Information and learning but not of any value to DFM given current situation.	
Hugh Sillitoe	Origin - Link with CIMTEL Multiplexity - Low Reciprocity - Unilateral in favour of Hugh Sillitoe	Support for IT system data	
Shaun Wrigglesworth	Origin - CIMTEL due to taking on Hugh Sillitoe's role Multiplexity - Low Reciprocity - Bilateral	Support to understand data transfer.	
Dean Williams and Dave Jones	Origin - SAGE & Technopoly due to conference visits Multiplexity - Low Reciprocity - Bilateral	Possible supplier of accounts system to work with DataWorks/Avante system.	

Table 7.27: DFM - External Orientation and Network Variables

7.7.5 DFM: Management Skills & Networks

Both Gareth Williams and Bill McKenna are key actors in the project from a management perspective. Bill McKenna's value was his understanding of similar projects in the past and his independence from the main functions in the organisation which allowed him to push the project whilst Gareth Williams made sure the project ran to plan. He was in a position to ensure that all actors were achieving the parts of the project without being seen as the driver. Gareth Williams is the link between the project and the Board. Both actors during the project got involved in a diverse and high number of relationships with module champions, suppliers, and the Board. So multiplexity was high for both these individuals. It is interesting that many of the relationships especially in relation to Gareth Williams are affective ties and friendship not simply based on contracts and hierarchy (summarised Table 7.28). This aids in providing an open environment within the organisation and assist in the management of the project (De Meyer, 1991).

Actor	Relationship	Transaction Content
Bill McKenna	Instrumental	Information - Project
	Multiplexity - High with team individuals and High with module champions.	To sell idea to the individuals and develop system
	Formalisation - High	Value - High
Gareth Williams	Instrumental & affective ties	Information - Company
	Multiplexity - High with team individuals, Medium with module champions and Medium to Low with Ken Chandler	Manage and formalise the project
	Formalisation - High	Value - High
Module Champions	Affective ties	Knowledge and Information about Department
	Multiplexity - High within departments	To provide knowledge and information about department processes and to formalise the project within their departments - including training.
	Formalisation - High within core team and across the company	Value - High

Table 7.28: DFM - Management Skills & Network Variables

Importantly for the project was the decision to develop the module champion role to provide the core team with access to individual areas/departments of the organisation to access knowledge of processes involved. But also these roles provided a management structure for the core team to get the project accepted in the departments and to provide a means to undertake training without having to have Bill McKenna and David Riley training every individual. The module champions were trained and were then able to use the training facilities with individual and groups from their departments to spend time training.

7.8 DFM SUMMARY

The network process employed by DFM is a progressive change within the company. The company relied on processes and systems in house that had been out of date for some time, although they had served the company well without pushing or developing the firms competitive position. Taking on this project was potentially risky, but necessary to ensure the systems continued to operate beyond 2000 and an opportunity to tighten procedures and processes ensuring integration and compatibility in-house as well as competitive advantages in relation to dealing with customers and suppliers. To do this has required the hiring of particular competencies (i.e. Bill McKenna) as well as working closely with external actors as suppliers of technology as well as knowledge (DataWorks & David Riley) that the organisation can learn from. Although in some areas of the organisation such as finance these competencies have been relied on too much and with Bill McKenna leaving (Map 5 - Figure 7.10) has left a whole in the understanding of some module champions. The use of module champions to internalise the project was largely successful in areas like accounts, stores and manufacturing however some areas failed to take on board the importance and value of the project at the time of Bill McKenna's involvement. They tended to rely on him to solve their problems and difficulties whilst they got on with their usually daily roles. This was the one drawback of the project that has led certain functions as well as the Management Services Function to consider and hire staff to undertake some of that work required for the project. The external orientation of the project, as discussed, is limited except during the vendor rating procedure. The project would only succeed if the project was internally focused and not run or driven by some external body. Hence, Bill McKenna was the boundary spanner (Maps 3 & 4 - Figures 7.8 and 7.9) and along with Gareth Williams were able to control the external impact and in many ways develop a network that utilised the internal actors to drive their area of the project. The Board backed the project throughout its development and evolution and importantly the organisation as a whole saw this to be so. Given that the actors in the organisation see the chairman, even during hard or difficult business periods, putting his hand in his pocket to meet short falls then they are prepared to listen and accept Board decisions more readily. This does however mean that during the project they are not questioning what is being done as my interviews with module champions showed (see John Thorman and Meirion Parry). Finally, the management of the project has benefited DFM and has proved successful in terms of internalising the project and utilising the internal knowledge (Map 3 - Figure 7.8). The company's success with the project is now being taken forward into developing business areas such as telecommunications. Although not mapped, this new internal network development is born out of the IT project and will be an addition to that project. So a large intensive IT project based on utilising new computer and software technology to support and integrate the organisation is now being mirrored in the telecommunications business. The aim is to create new practices and procedures to develop better products, efficiently and effectively and in doing so given the business a competitive edge with the likes of BT, Northern Telecom and European and US telecommunication customers.

The change in DFM has been dramatic with not just this project but new projects being considered and championed by Gareth Williams along with members of the Board. This came on the back of the company's realisation that new customers are needed to meet the changes and add value to these changes internally. The company in the last three years has finally developed a corporate strategy and business strategy - formalising a plan for the next five years and beyond. With this new outlook the company has employed its first Marketing and Sales Director who remit is one of seeking out new customers and selling the name of DFM to the potential market. Also the cellular manufacturing process is being implemented. During the summer of 1998 Gareth Williams spoke with a member (Genba Kanri) of the Wales Development Agency (W.D.A) who mentioned a workplace management package (developed by PS Industries) available through them via Paul Ward of Lorien Consultancy. Initially the possibility was examined along with Morris Jones in manufacturing and discussions with Paul Ward. The cellular manufacturing project was initially approved with four projects in mind each one related to the manufacturing area. Three projects were entered into: PCB Project; Assembly Line project; and Machine Shop project. Project sponsors were nominated; the development of workshop training for each team; teams must declare actions/progress; teams were coached reporting every 2 months so senior management to track the project development.

> *'The objective is to change present practices for the better of manufacturing and to demonstrate improvement. ....To develop best practice operations and processes'* (Gareth Williams, Nov. 1998).

The projects are based on an ethos and structure of continuous improvement in the workplace and support the new IT system by improving work along with processes. Table 7.29 - identifies each project and its set of actors.

Project	Sponsor	Team Leader	Team	Aim
PCB Project	Gareth Williams	Gwyn Hughs	Ian Owen, Eileen Parry, Richard Shephears, Meirion Parry, Deiniol Jones, Aled Thomas & Derek Adams	To improve Productivity, Profit and Reduce Waste
Assembly Line Project		T.L. Val Charlton	Marie Copper, Layla Arafat, Arfon Hughes, Martin Pritchard	To improve Productivity, Profit and On Time Delivery
Machine Shop Project	Morris Jones	John Thorman	Graham Sherritt; Meiron Parry; Bob West; Dave Roberts; & John Jacobs	To improve Productivity, and labour usage

Table 7.29: DFM - Telecom Project Developments and Actors

The starting point was 'Do we need to do it' keep what is needed and remove the unwanted. Already savings are being made in paper usage reduction. It is reminiscent of the Japanese Toyota System - nothing new but proving valuable.

7.9 CONCLUSION

The cases presented in this chapter were chosen because of their very different projects. One is strictly product related whilst the other is process related. However, both utilise technology of one form or another. Clearly SUA had a strategy to develop its business and develop new products and technologies that would avoid the potential situation of loosing a major customer and the business suffering because nothing was done to meet this identified problem. DFM on the other hand has never had a formalised strategy and approached business in the way a jobbing shop might through word of mouth and traditional historic contracts. However, in this age of declining manufacturing in the UK the company realised the value in being strategic about new technologies, especially process technologies. However, more importantly the firm realised it must develop its marketing competencies to go out and find customers and sell the firm. As part of this overall drive to be market orientated the firm undertook the project in the case to develop internal processes to meet customer needs and to develop new technologies and products. Table 7.30 summarises the differences between the firms.

	SUA	DFM
Strategy	Limited strategy to develop new products and technologies until the development of the Harrier Project. Future strategy to develop new products incorporating new in-house developed technologies.	Strategy limited - certainly not formalised. However, project has meant a change in the Board's attitude and new customers are putting pressure on DFM to focus on its marketing strategy.
Resources	Resources high with the skills and knowledge required very much in-house. Also future developments show a strong skill and knowledge base within the organisation.	Resources in terms of manufacturing knowledge and skills high. But for the organisation to develop new technologies and products then new staff would be required as in the case of Bill McKenna.
External Orientation	External orientation focuses on customers. However, the current diversity of the customer base is limited. This needs to change with products like the Harrier Project.	Very limited - Although a greater use of the IT system to communicate and work more closely with suppliers and customers will increase the company's external visibility.
Competencies / Knowledge	A strong base of competencies given current product developments and given future products in the pipeline.	Competencies are manufacturing and engineering based and are valuable. But the market is changing and such skills are evolving the firm has to continue to move with such evolution to survive.
Competition	Competition is strong in terms of cost based competition. However, the drive for new product development means the firm can compete on product innovation rather than price.	Has been ignored in the past. But the IT project allows the firm to develop its management information system to understand its markets and customer plus competitors to ultimately drive a new marketing strategy and to make decisions on accessing new technologies.

Table 7.30: Summary of Cases and Differences in Networks

Just comparing the network maps of the two cases they appear completely different to one another. One being very internally focused whilst the other being externally focused especially in relation to customers. In general both firms are very similar in that they have relied on key customers for business over the years. Both were attempting to remove the reliance on one or two customers and expand their potential to attract and develop new business. They, as can be seen from the maps, had very different ways of going about this. SUA developed new systems and technologies to improve current products whilst DFM focused on improving internal processes at the manufacturing level as well as at the organisational level to provide customers with options for handling their business.

Strategy will be an important element in DFM continuing to survive in the 'harsh world' of manufacturing and may well see DFM generating business especially in its developing electronics base. The same is true for SUA, as it too has been complacent during the 1980s and 1990s relying on current customers to still be a customer in a years time. Generating business is not simply about what you produce today but also about what you can produce tomorrow and this is important in the success of these firms. How they manage the technologies strategically in the future will determine their success or failure.

Chapter 8:
SUPPLEMENTARY CASES

CHAPTER 8

SUPPLEMENTARY CASES

8.0 INTRODUCTION

In Chapter 7 I outlined and analysed in detail two traditional mid-corporate manufacturing firms. The two firms had very different perspectives regarding developing innovation and being innovative, with one developing its strategic orientation and the other having limited strategic orientation relying on customers and past history. However, both highlight the differences in product and process innovations and the maps show major differences in the network organisation and use of actors. The following three cases in this chapter, although dealt with in the same depth and detail offer supplementary data to the first two cases. In OCL there is a clear link between the project network and the strategy being adopted. From the outset the strategy is one of acquiring 'pacing' technologies (Little, 1981) and far removed from the organisation's technology product portfolios (Dussauge et al., 1987). DDL is similar in many respects to DFM although purely internal individuals orchestrate the process-orientated changes with very limited external orientation apart from supply. In this case no consultants were used to aid change. Finally, WEL shows a very different approach to innovation than any of the other cases. The company set up a new product development committee (NPD) to oversee new product development and the acquisition of new technology to provide the company with opportunities in new and developing markets and to increase its market competitiveness in one of its weakest business areas.

8.1 OTTER CONTROLS LTD (OCL)

OCL set up a number of projects during the early 1990s to meet a new strategy of developing new technologies and to open up new market opportunities. The TMS began in 1992 and in the period up to 1996 (discussed in Chapter 6) failed to achieve its objectives. The project, at the end of 1996 underwent a major transformation and it is the period 1996-1999 that forms the main focus of this case. Before I describe and analyse the networks that formed around this period of the project I will identify in Table 8.1 all the internal actors utilised during the project (1992-1999) as well as those that had links to external actors in Table 8.2.

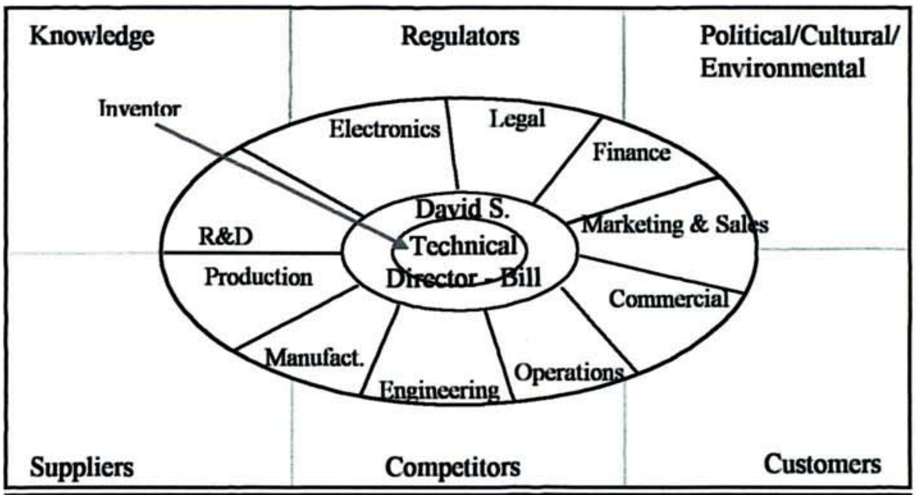
Actor	Relationship
Andy Derbyshire	**Prod. Develop Engineer**
Andrew Bromley	**Assistant Electronics Manager**
Mark Guyer	**Product Manager**
Graham Kennet	**Project Leader '96-'99** - instrumental tie
Paul Martin	**Sales Engineer**
Chas Kilby	**Development Engineer Testing**
Jeremy Siddons	**Electronics**
Mike Holmes	**Electronics**
Andrew Phillips	**Manufacturing**

Table 8.1: OCL - Identified Internal Actors and Positions

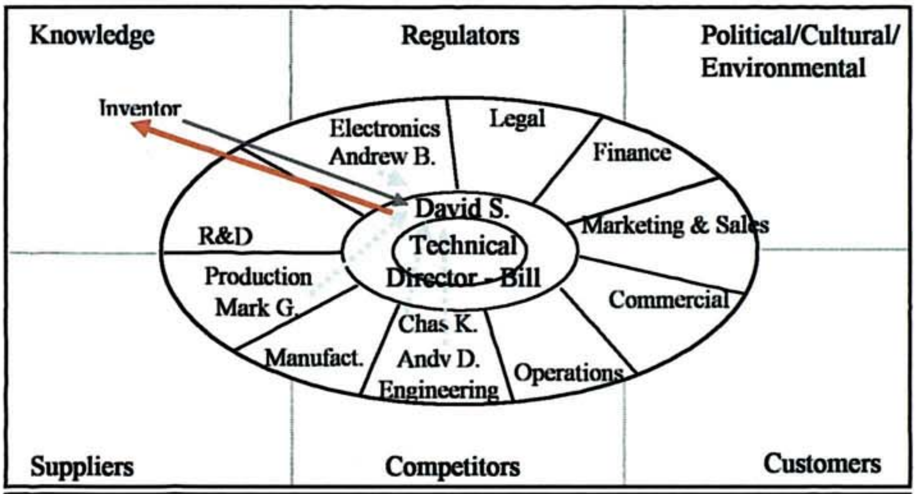
External Actor & Type	Template Position	Internal Actors	Map
University - CAMPUS	Knowledge	David Smith	Map 3, 4
University - CAMPUS	Knowledge	Andrew Bromley	Map 3,4
Inventor	Knowledge	Technical Director	Map 1 & 2
Inventor	Knowledge	David Smith	Map 2
ESPRIT Programme	Regulations	David Smith	Map 5 & 6
Formula 1 Team	Knowledge	Graham Kennet	Map 6
NEXUS - Firm	Suppliers	Mike Holmes	Map 7
Tyre Manufacturers	Knowledge	Paul Martin / Graham Kennet	Map 7
Steven - DC Cut-outs Sales Manager	Knowledge	Paul Martin	Map 7
Jeff - Press Tool Designer	Knowledge	Andrew	Map 7
Radio Communications Association	Regulatory	Mike Holmes	Map 7
Car Manufacturers	Customers (Potential)	Paul Martin / Graham Kennet	Map 7
Dieter Rodline - Representative	Customers	Graham/David Smith	Map 7
Raio Types - Firm	Supplier	Andrew Phillips	Map 7
SMARTYRE	Competitor	Graham Kennet	Map 7/8/9
Morgan Cars	Customer	Team	Map 8/9

Table 8.2: OCL - External Relationships by Collected Network Data

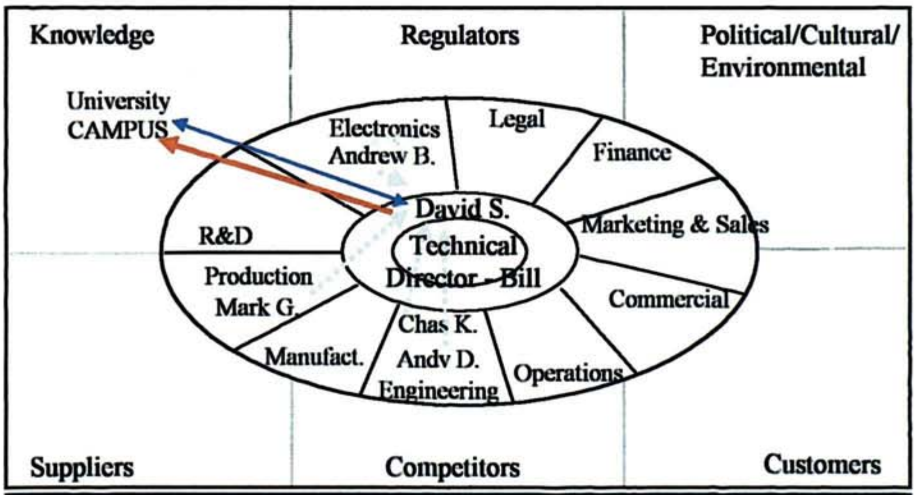
The network is analysed from the period at which the TMS project was resurrected after various changes within the organisation and significant problems surrounding the project. The early part of the project is summarised in Chapter 6 and the network maps (1-5) of the TMS 1992-1996 are seen in Figure 8.1.



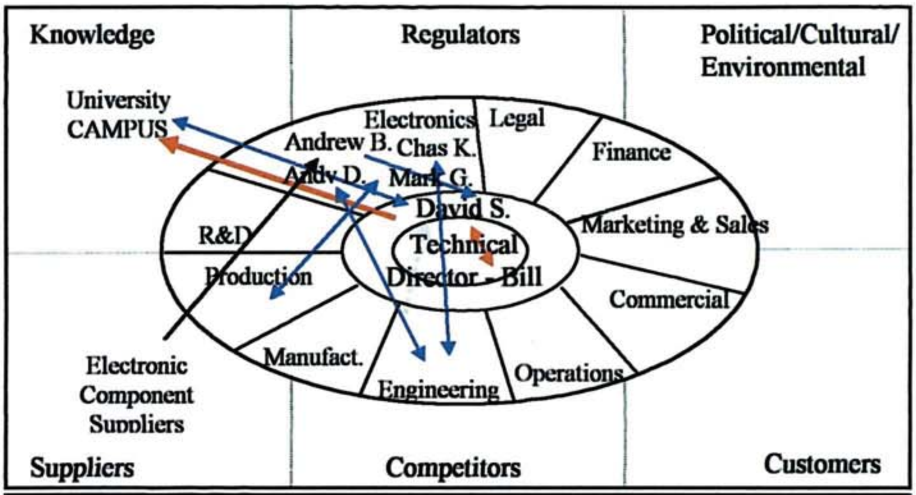
Map 1: Enquiry Network - Informal. Size - 2 actors; Diversity - Low; Openness - High between individuals; Centrality - High; and Shape - Externally orientated towards knowledge with change in strategy.



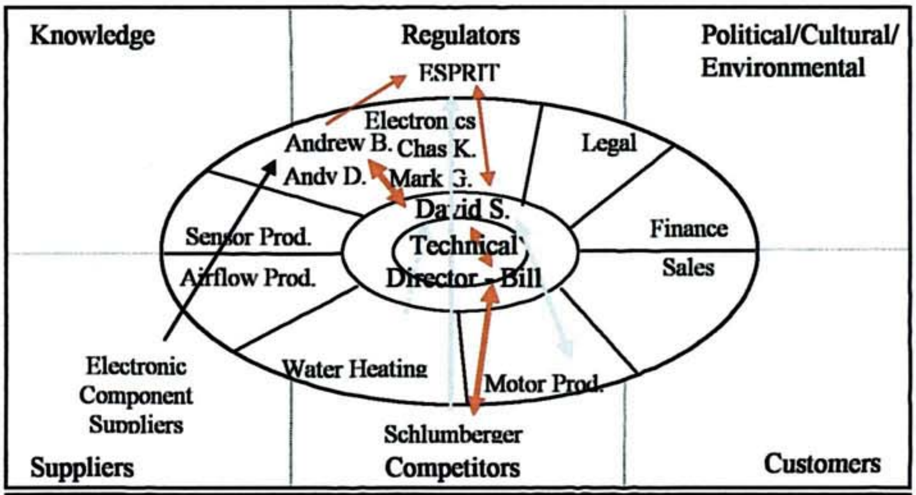
Map 2: Feasibility Network - Informal. Size - 7 actors; Diversity - Internally Increased; Openness - High between individuals; Centrality - High; and Shape - Externally orientated but internally focused on idea generation.



Map 3: Feasibility Network - Formal. Size - 8 actors; Diversity - Internally High; Openness - High between individuals; Centrality - High; and Shape - Externally driven.



Map 4: Development Network - Formal. Size - 9 actors; Diversity - Internally High and increasing externally; Openness - High with knowledge and new departments; Centrality - High; and Shape - Externally driven by CAMPUS.



Map 5: Project Internalisation Network - Formal. Size - 9 actors; Diversity - Internally and Externally Reduced; Openness - High within Electronics Dept.; Centrality - High through David: and Shape - Internally driven still no market orientation.

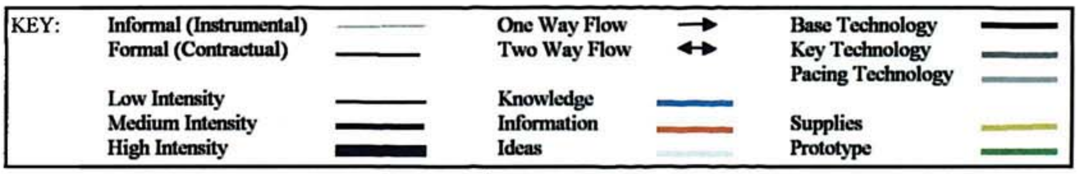


Figure 8.1: Summary of OCL's Strategic Innovation Networks (SINs) Prior to 1996

8.2 TYRE MONITORING SYSTEM (TMS) 1996-1999

During 1996 the organisation restructured and disbanded the electronics department. Key to the TMS continuing beyond 1996 was David Smith. David Smith as the Technical Director continued to believe that the project had market potential and during the restructuring managed to divert additional engineers from the electronics department to the TMS "referred to this as a *'skunkworks'* (see Peters and Waterman, 1982). Two electronics engineers (Jeremy

Siddons and Mike Holmes) were informally working on the TMS unbeknown to the Board. Three developments from this *'skunkworks'* encouraged the Board members that the TMS could be revived and supported David Smith's faith in the TMS (Map 6 - Figure 8.2 details in Table 8.3). First, a Formula 1 Team expressed an interest in testing the TMS. The second issue was related to the cost of importing specialised integrated circuits from Switzerland. OCL engineers found a way of resolving the technical problems without recourse to specialised equipment and that reduced the overall risks and capital investment. The third development was that product liability was seen to be much less of a problem than had been first anticipated.

Network 6 Dimensions	The Network
Size	The network size reduced dramatically after the near cancellation of the TMS/TMS project. Two actors plus David Smith internally with external suppliers were informally involved. Initial discussions with a Formula 1 Team for testing were started. The network size was 6 in total.
Diversity	The diversity of the internal network was non existent. Both key actors were purely electronics orientated and had no link for some months with any other actors in relation to the TMS.
Openness	This lack of diversity led to an obvious lack of openness and a belief by David Smith that a breakthrough could rejuvenate the project. Openness was limited.
Centrality	The Board were not fully aware of what was happening in the electronics department in relation to the TMS project. It was not part of the formal hierarchy of the organisation.
Shape	The shape points to a technology driven network based purely on electronics with no production or manufacturing input. The point of the network was to solve problems and find solutions. Therefore the main focus externally was on suppliers in terms of finding ways to increase battery life.

Table 8.3: OCL - Network Map 6 Dimensions and Detail

In overcoming the problems the Board agreed to re-organise the project. The main criteria set by the Board was to achieve a saleable product by April 1998.

> *'When the TMS was resurrected a project plan was drawn up with specific targets and dates. Simply, the Board have kept out of the running of the project and will only act if the final completion date for the product is not met - then they will cancel the TMS!'* (Graham Kennet, Jan. 1998).

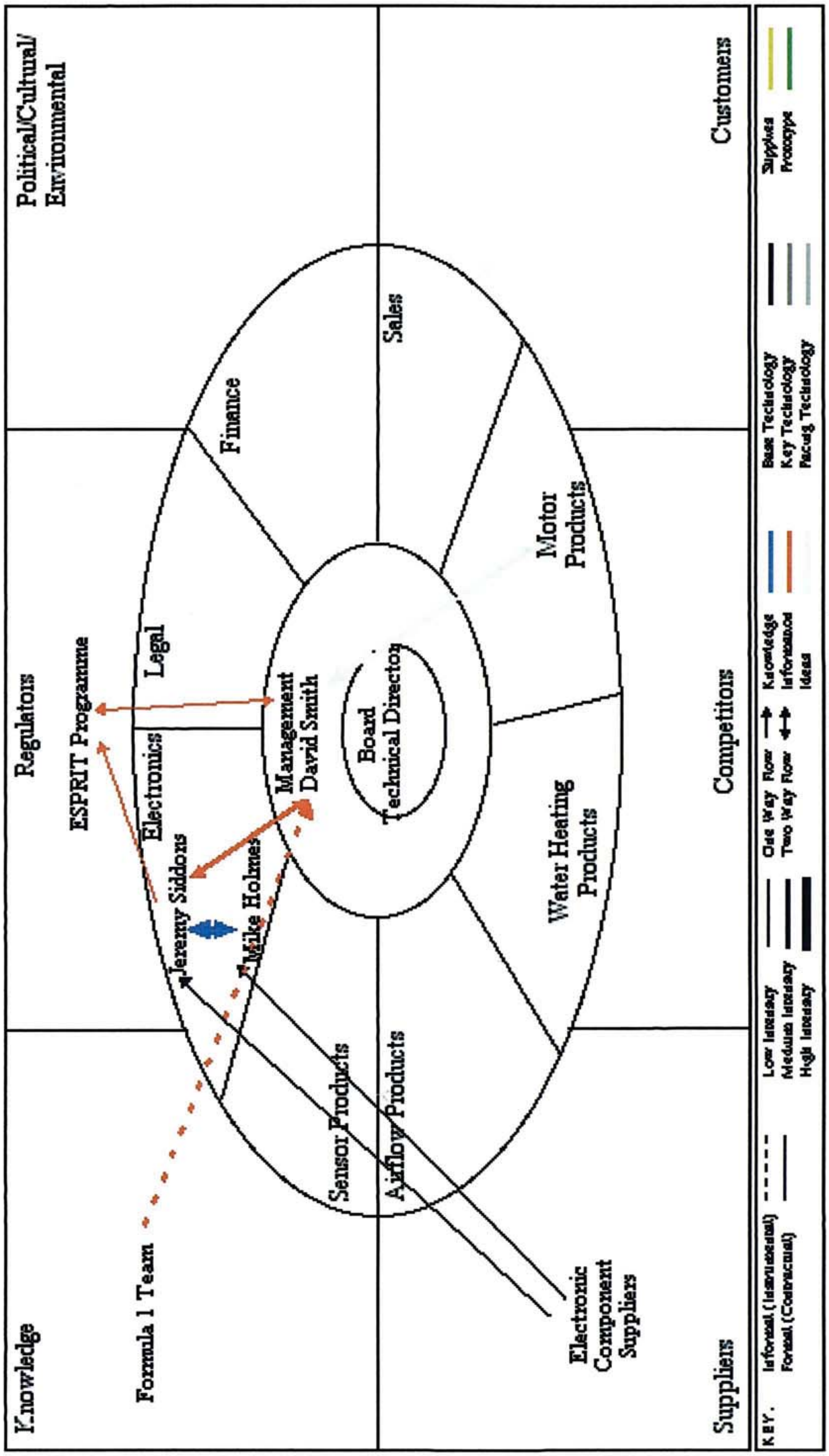


Figure 8.2: OCL Map 6

The TMS internal actors changed with the formalisation of the *'skunkworks'* in 1997 creating a new and stand alone department within the organisation. The actors were Graham Kennet as project leader (accountable to David Smith with all internal TMS actors accountable to Graham Kennet); Paul Martin (key actor behind searching, gathering and collating data on the pressure sensor and tyre pressure sensor market. Paul Martin was brought onto the project due to his sales background and links to automotive manufacturers in the US); Jeremy Siddons (Jeremy Siddons had strong abilities and competencies in Software design, Analogue and Digital Electronics and Radio Frequency (RF) Electronics. This was also the reason he was not made redundant when the Electronics department folded.); Andrew Phillips (joined the TMS project late September 1997. His role was one of producing the housing for the transmitter working along side Mike Holmes and Jeremy Siddons and to design the external casing of the TMS); Mike Holmes (brought in for his experience in PCB board production and manufacture. Mike Holmes solved the battery life problem increasing it from 2-3 years to 10 years.); and Chas Kilby (he had been linked with the TMS project formally and informally since 1992. His role during this period included: car testing; sample preparations; software testing and car electrician work). Apart from Graham Kennet all were fulltime.

The team had no formal links to the rest of the organisation's products and developments. From 1997 onwards the team worked in relative isolation within the same building on the same floor with a wall between them. When meetings were held there was no formal agenda it tended to be an update. Graham Kennet would see the team daily in their work areas and concerns; problems; difficulties were relayed within the office. Graham Kennet identified that very little marketing; competitive analysis; market analysis; supplier analysis; cost analysis and sale analysis had be done previously and that the project for many years had taken a technology driven approach. The initial work for the team involved Graham Kennet and Paul Martin examining the competition and market. This was achieved given the time constraints by using the internet and talking to companies at a number of conferences/exhibitions. Graham Kennet and Paul Martin drew up the project plan in relation to the Boards requirements especially in relation to a particular time frame that is examined frequently by Graham Kennet and incrementally updated where needed. At this point the TMS underwent trials with a leading Formula One team. A prototype TMS was fitted to company cars which worked effectively but David Smith believed that in the short term the product was more likely to have applications in the truck rather than the motor industry. Despite the reemergence of the TMS as an important new product, senior managers continued to concentrate on those core product areas associated with bimetallic technologies - the constant aim was to improve profitability. This was a problem given the pressure from the auto-manufacturers for continual price reductions - which intensified. The issues for OCL and the TMS during this period were:

- the competition
- pricing
- the manufacturing of the TMS long-term - in-house or out-source
- the development of a dashboard display and dashboard housing
- the development of software
- the testing and calibration systems including electronics and software
- getting the product to market by April 1998 or miss a major part of the market and rather than being a market leader being a market (technological) follower (Porter, 1985)
- the value added by the TMS

There was a rational decision made to fully consider the market and to use exhibitions and links with automotive and tyre manufacturers to assist informally with its development. The belief was that a greater market orientation would aid the project's direction. Graham Kennet's external links developed with existing relationships and potential links identified by Paul Martin in his examination of the potential and existing market. Paul Martin identified the main competition as SMARTYRE a US product. The team believed they could improve on and make the TMS very competitive through innovative developments relating to temperature and pressure readings plus storing such readings. Paul Martin along with Graham Kennet began exploratory discussions with automotive companies and tyre manufactures. This was especially so in the US to gather information on what they would like and prefer to see in such a product in relation to how regulations, law and tyre developments might effect the market over the next five to ten years. The tyre manufacturer was (and still are) developing the Flat Run Tyre (FRT) which means the tyre can continue to be fully road worthy for up to 70-100 miles of normal use without air in. The value of the TMS for such FRTs was that the driver would need a device to warn them that the tyre has lost pressure and needs replacing. Without a warning and measuring device the manufacturer of the tyre could be liable if the tyre has no pressure an yet visibly appear road worthy. Relationships throughout the project were informal with no contractual agreements. External actor links included testing of the TMS by GoodYear who were developing the FRT and looking to make it the next major tyre development. Graham Kennet and Paul Martin were in discussions with their development teams on that tyre and have tested the tyres. Other contacts were in the area of the big car manufacturers (Ford, GM and Peugeot) as well as the small car companies/niche firms (Aston Martin, Jaguar, Corvette) that are owned by the larger firms. Presentations were made by Graham Kennet to manufacturers in the states September 1997 and in Feb 1998 at the SAE Exhibition in Detroit.

Network 7 Dimensions	The Network
Size	After the total overhaul of the structure and the TMS project the size of the internal network increased with what was believed to be better equipped personnel in terms of knowledge and competencies. Also the external network developed and increased. The total network size nearly doubled with 15 actors having a key input.
Diversity	Diversity of the actors involved in the TMS department was broad and this was matched by the very different external orientation to the network. Both knowledge actors and customers provided a diverse array of knowledge and information on the developments of the tyre pressure market as well as new tyre developments. However, diversity across the organisation was extremely limited.
Openness	As stated diversity across the organisation was limited and this limited the openness within the organisation. However, the team worked closely and was very open and aware of each others value to the team.
Centrality	This area of the project reduced considerably. The network shifted forming its own department with limited relevance to the organisation's current strategy. The link to David Smith and the Board became more informal.
Shape	The shape of the network concentrated heavily on the TMS Department and its external orientation. Limited spread across the organisation.

Table 8.4: OCL - Network Map 7 Dimensions and Detail

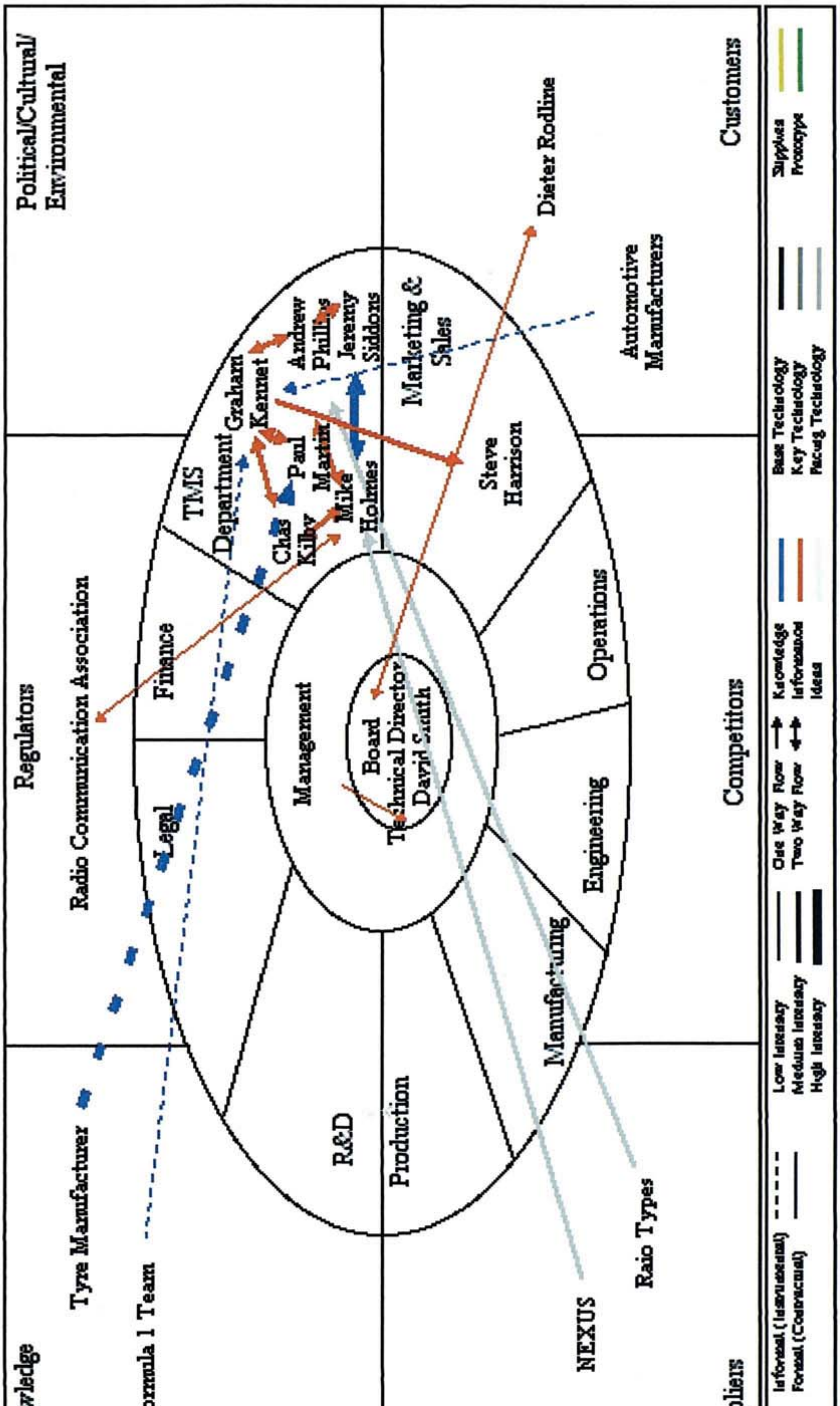


Figure 8.3: OCL Map 7

A German representative was used to aid access to German companies and talking with German company representatives (Dieter Rodline). During 1998 talks were opened with a Team Manager of a mid-range motor-sport set-up. During the design and development phase a new moulding tool for manufacture was developed; sales (Steven Harrison - Sales Manager) was brought in to assist in developing manufacturing projections and sales and marketing forecasts during March 1998. Discussions with external actors supported the direction of the project and throughout internal communication was key. Mike Holmes and Jeremy Siddons worked closely together to meet problems when they arose the main one being the attenuation of signals when under extreme tolerances in the tyre. Communication between Mike Holmes and Jeremy Siddons was very important throughout as changes in one area of circuitry could and in many cases did have software implications and readout implications. Reaching pre-production meant Mike Holmes had to re-design the circuit board layout to fit the designed sensor housing for production. In producing the transmitter and receiver circuitry he dealt with a number of key external bodies and was supported by the internal actors. A relationship with Nexus Dynamics based in Stockport was developed to access advice on reducing the size and spacing between circuit layouts and the aim to produce a batch of internally designed PCB boards. Chas Kilby's physics competencies supported both Mike Holmes and Jeremy Siddons in testing and calibrating the chips on the new PCB boards for high volume production. The Radio Communication Association (RCA) was vital in gaining approval for transmitting at a certain frequency. Mike Holmes had to complete forms regarding the characteristics of the TMS circuitry and its use. Problems did arise in relation to the definition of the system as to whether it's an 'in-vehicle' system or not. Mike Holmes worked with Graham Kennet to provide precedence in relation to other products. This involved pre-compliance testing, arranged with the ERA, which found the TMS would meet the RCA's requirements. Andrew Phillips was brought into the team during this PCB development to design potential versions of the mouldings for the TMS display/handset. He based the designs on mobile phones utilising SLAs. Seven designs were created then chosen through internal in-house voting at the start of 1998 and then in January 1998 the prototype design was ready for prototype manufacture. A Leicester based company - Rapitypes was approached to produce the first few prototype housings. The company was found by enquiries made by Andrew Phillips to mobile phone companies such as Motorola and by pulling a number of different mobile phones apart to find names of companies that produce such parts. The prototypes cost £4000 for 20 and these were initially shown at the SAE Conference in Detroit. The response from potential customers was extremely positive compared with existing competition. This led to some refining work in order to get to final production including keypad; ultrasonic welding; mould making (due in the next few weeks). This was done externally due to the fact that OCL's competence was confined to Glass Field Nylon moulding and not Acrylic, SLAs and Graphics that were required for the production of the final assembly. Suppliers became an important external element of the design and manufacture stage. Andrew Phillips had to assess different suppliers and materials. Andrews Phillips' links with external customers was limited to visits to Aston Martin at Express Tyres in Coventry to fit the TMS. His main contacts were Jeremy Siddons and Mike Holmes. Jeff in the NC Tool Room was also an important internal relationship in terms of developing press tools for manufacture and making sure that machines had the correct software changes. Andrew Phillips felt that he was often outside the main team in terms of information especially when a new PCB board had been produced but the requirements for the housing that he was designing had been passed to him but he had not been informed of the changes. He found out from another source and not the team. Map 7 (Figure 8.3 details in Table 8.4) provides a visualisation of the network during this period.

The April 1998 deadline came and went with the report delayed due to the development of a customer-supplier relationship with a niche car manufacturer (Morgan Cars). The Board extended deadline to December 1998 to complete the final report on the project and projections of sales over the next 5 years. Map 8 (Figure 8.4 details in Table 8.5) represents the period over the summer of 1998. Chas Kilby decided to leave OCL to pursue a new career. Chas Kilby's role was filled briefly (6-7 weeks) by Mark Truman. This was an internal recruitment but Mark Truman left OCL for a new job. Ray Bould also joined the team during late summer 1998. He was employed on the TMS to build TMS units. Andrew Phillips stayed at OCL but left the TMS project. He moved back to more technical projects related to DC/AC cut-outs. Examining cost cutting in these areas. Paul Martin stayed at OCL as part of the sales team.

Network 8 Dimensions	The Network
Size	During the summer of 1998 the network changed dramatically with individuals leaving the network as manufacture came close and individuals were brought in to assist in manufacture. Number of actors was 9.
Diversity	The diversity of the actors involved in the TMS department reduced in some areas but developed on the manufacturing side. External orientation was not particularly diverse but some motorsport and car orders were taken.
Openness	The teams openness was still high as everyone was very aware of the need to push for sales and meet the needs of the Board given the up coming decision late that year.
Centrality	Centrality was still limited with infrequent contacts between David Smith and Graham Kennet.
Shape	The shape of the network supports the view that the TMS Department was orientated towards external sales to customers.

Table 8.5: OCL - Network Map 8 Dimensions and Detail

Christmas 1998 saw the Board supplied with a report on the TMS giving its current situation, tooling costings, manufacturing costings, and market situation. However, the start of 1999 was not going to be a happy one for the team as the product was cancelled. Map 9 (Figure 8.5 details in Table 8.6) represents the network after the termination of the project. Many reasons were given for the Boards decision including: The TMS did not fit the current OCL product mix especially as it would be a premium product.; OCL's situation was one of 'securing current business'. This came about due to an economic downturn and a patent battle which required a high financial resources (approx. £50000/month) and time of the senior management and the TMS would not offset this with a high profit margin.; the mass market for the TMS was unlikely to develop before 2001 given the tyre manufacturers where unlikely to see Flat Run Tyres on mass market cars until this date.

Network 9 Dimensions	The Network
Size	Actors left leaving a small core team to complete current orders. Number of actors was 7.
Diversity	The diversity of the actors involved in the TMS department reduced once again with only a small core team.
Openness	Openness was still high but disappointment was evident.
Centrality	Centrality had increased given the attempt to sell the product on to another company.
Shape	The shape of the network concentrated heavily on current orders and a key link with SMARTYRE who were seen as a possible buyer.

Table 8.6: OCL - Network Map 9 Dimensions and Detail

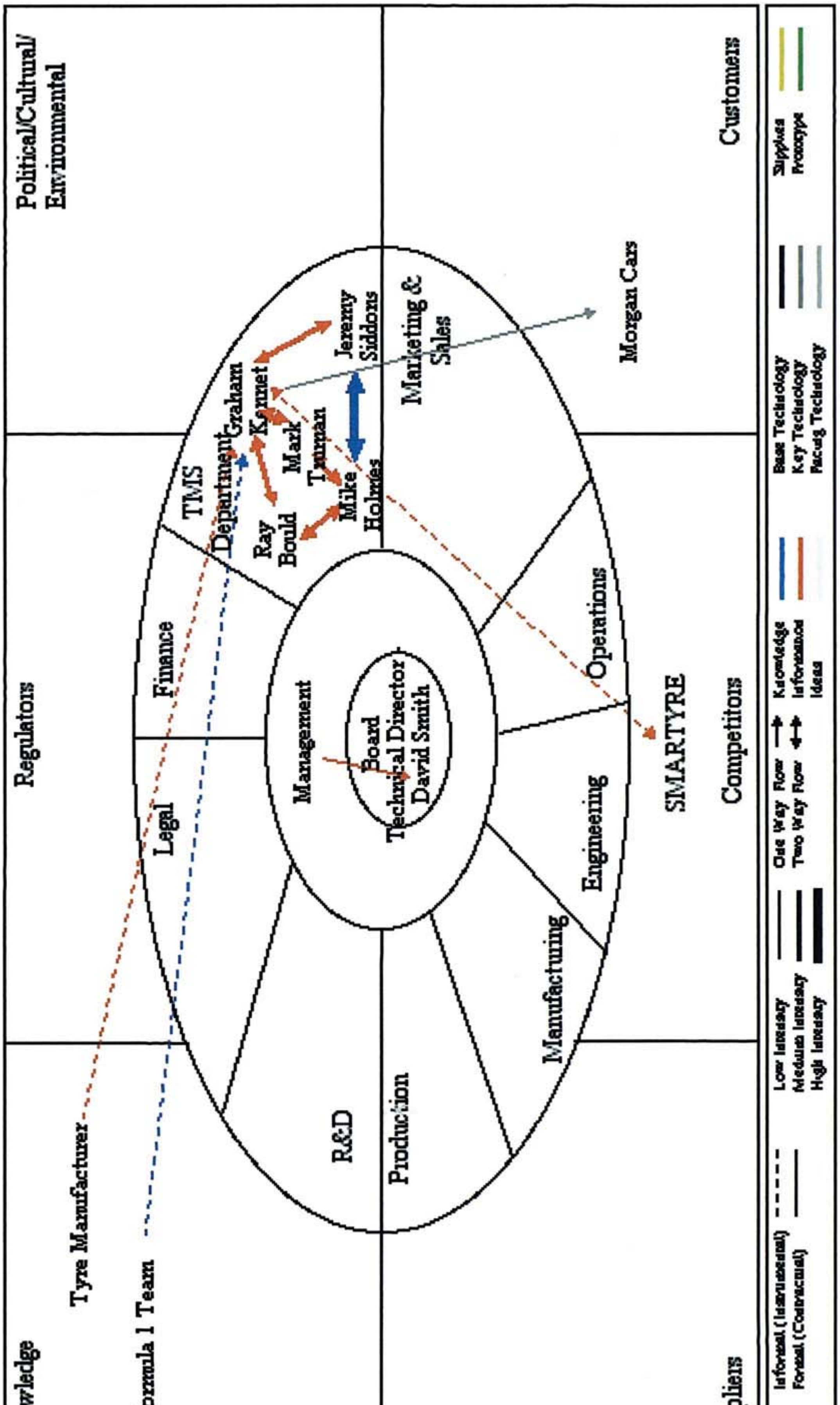


Figure 8.4: OCL Map 8

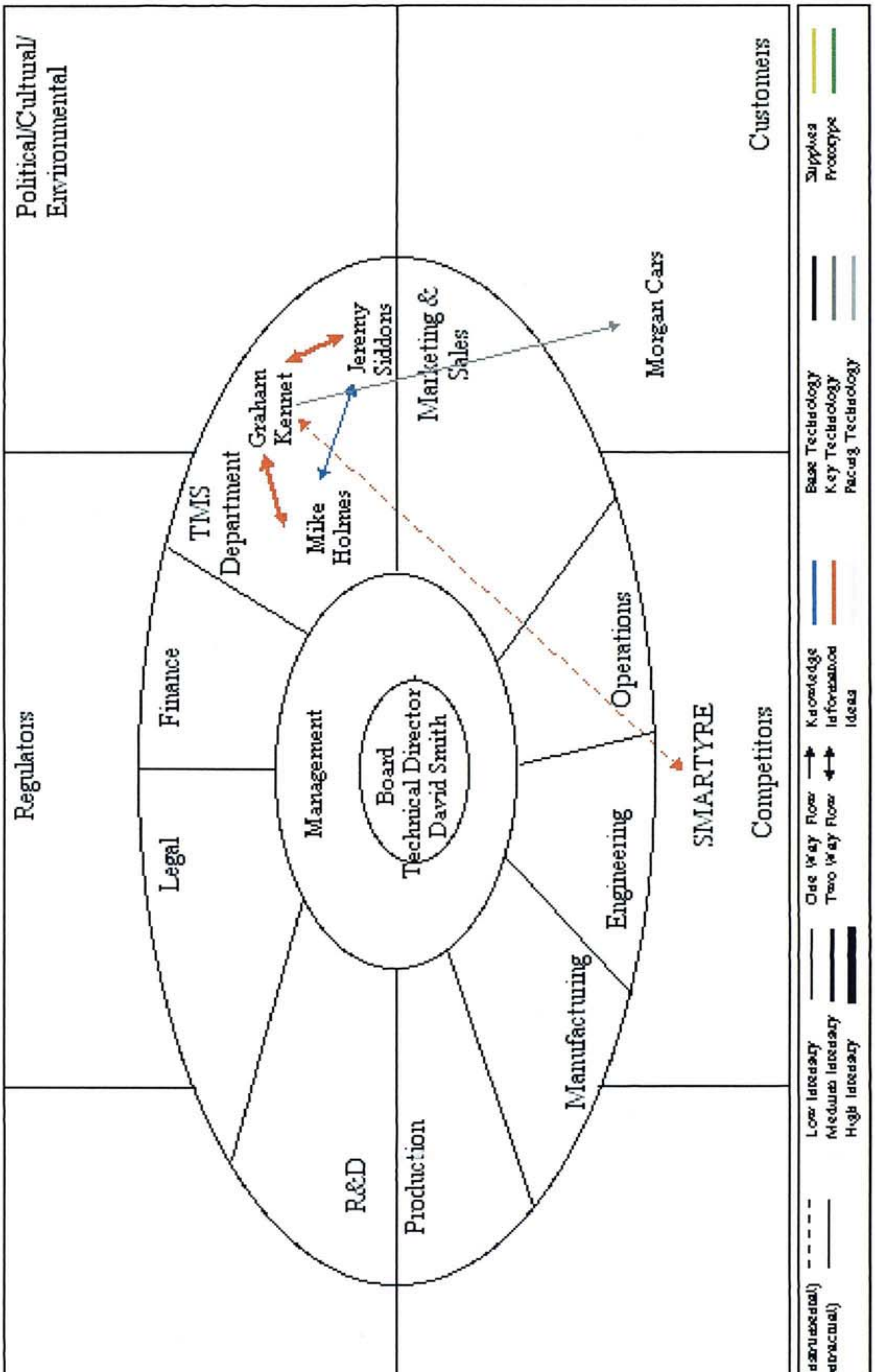


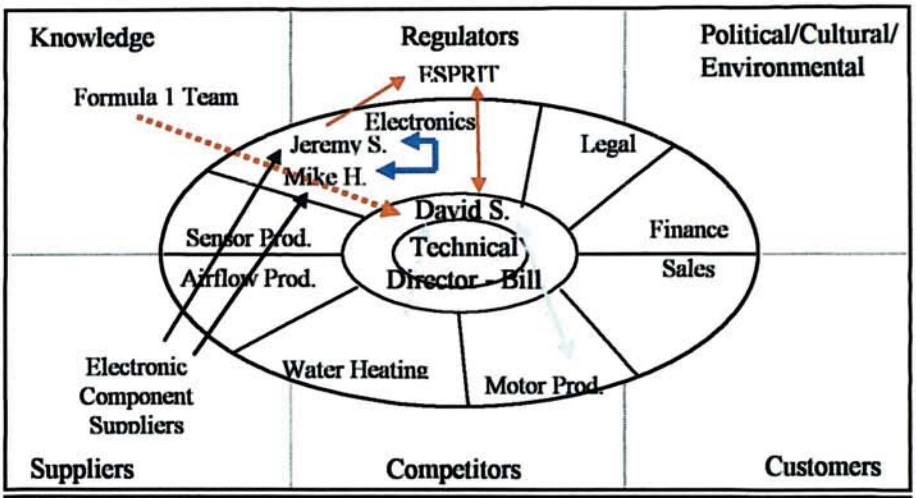
Figure 8.5: OCL Map 9

OCL would not support the product for at least two years. Graham Kennet in hignsight saw the TMS as *'too technology led, right from the moment it reverted to an electronics product rather than a bi-metal based product'*. Given the cost of a premium tyre pressure sensor the market is looking at 'lower spec' and 'cheaper products' and Graham Kennet seriously felt that the TMS 'should have started from a lower spec' this was severely hampered by 'a lack of clear definition of objectives and achievement'. Graham Kennet and the rest of the team were very disappointed with the failure to secure the future of the TMS at OCL. Jeremy Siddons and Mike Holmes agreed 'the product has value and a market - 'the time is just not right' Graham Kennet believed that the TMS was a viable product to someone - *'The most likely buyer would be SMARTYRE'*. It would provide them with a product that was superior to their own and mean that the development costs of a new product could be cut out. However, the TMS was 50% software design and technical development and would mean the buyer would need a competence in this area. This could provide an opening for Jeremy Siddons as he was the engineer behind the software design. Morgan continued to purchase units for orders made before the project was scrapped. The cancellation meant that Jeremy Siddons and Mike Holmes with their electronics knowledge and competencies where no longer needed. Both were kept on until the end of April 1999 unless they had found new jobs to aid the company in selling the product to possible customers (competitors). However, Jeremy Siddons and Mike Holmes left OCL at the end of April 1999 having obtained jobs but having to relocate quite significantly. The plan was drawn up for what to do with the TMS but as of the beginning of May 1999 no agreement had been reached with a possible buyer. Graham Kennet was unsure of the outcome except to say that if SMARTYRE did not purchase it then the most likely buyer might have been a motor-sport team. However, the way Graham Kennet was talking is was quite possible that the TMS would simply end

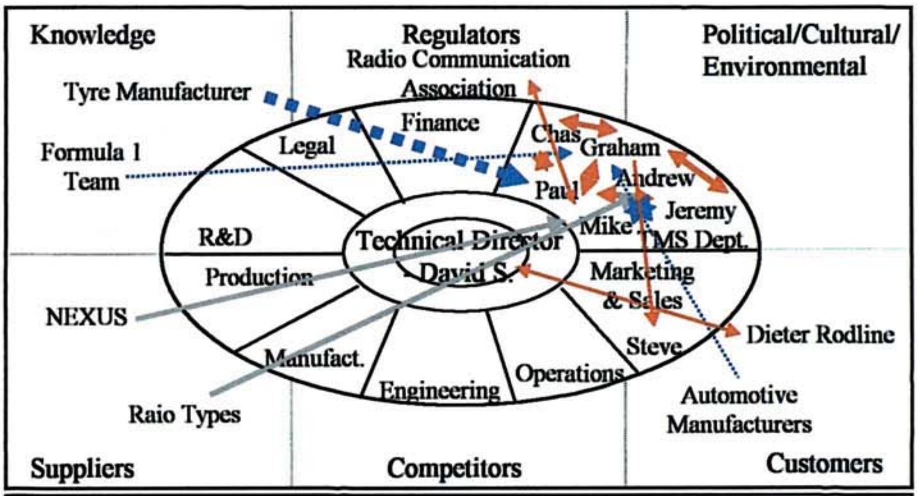
> *'........if an agreement was not secured by the end of May or early June then the momentum left by Jeremy, Mike, Graham and the team to sell the product may be lost and the enthusiasm of the company to make any further attempts to sell the product would be unlikely'* (Graham Kennet, Feb. 1999).

8.3 OCL: NETWORK SUMMARY & FRAMEWORK ANALYSIS

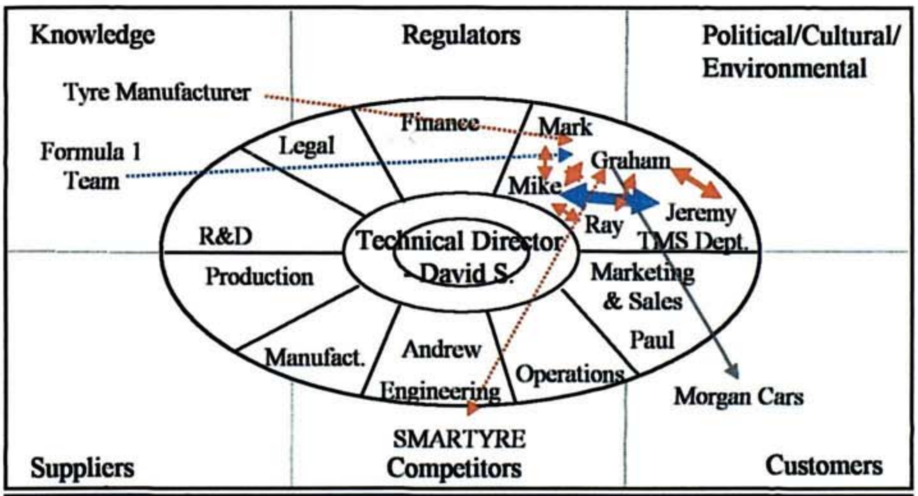
OCLs' network appears to be one of the least stable of those examined through the cases. The network maps are summarised in Figure 8.6. From a very externally orientated and technologically driven network through Maps 1-5 (Figure 8.1) the project and its surrounding networks shifted to a more internally orientated project utilising skills developed between 1992 to 1996. Map 6 (Figure 8.2) indicates the change in the formalisation of the project during this transition period (re-structuring and new strategy) within the organisation. The internal changes to the organisation reduced the formalised multiplexity of the actors linking them increasingly with products. Ultimately these existing products had no useful relevance in terms of technology or knowledge to the TMS during the re-structuring to a product structure and when the new set of actors were in place during Maps 6-7 (Figures 8.2 and 8.3). Maps 1-6 show limited external orientation supporting the lack of customer and market information gathering to assist in the developments of the project. Map 7 (Figure 8.3) highlights a real change in strategy for the organisation with the organisation reverting back to core product technologies. The TMS continued with limited formalised links to other areas or actor in the organisation. The department acted as a product function even though these had been removed from the internal structure of the organisation. However, this change shifted the shape of the network increasing its actors, diversity and market orientation moving away to some degree from the technology driven project that it once was. Paul Martin's inclusion was key to this change. Map 7 (Figure 8.3) highlights the diversity of external market actor relationships to provide the team with a strong position in gathering information on the market with Paul Martin and Graham Kennet sharing the boundary spanner and information gate-keeper role. These roles did however differ where Paul Martin's role was directed to the car companies whilst Graham Kennet dealt with suppliers and competitors. Map 6 (Figure 8.2) and 7 (Figure 8.3) show low centrality of the project at this late stage with limited input or relationship with the Board, David Smith or other senior managers and directors. Map 8 (Figure 8.4) clearly shows the project entering the manufacturing phase but with no links to manufacturing as the volumes where small enough to be met by the existing team and were hand built. During this period we also see changes to the actor network to assist the manufacturing phase. Map 9 (Figure 8.5) finally shows the network after limited manufacture and the decision to terminate the TMS. There were limited internal actors and external links were formal in relation to low volume sales and informal in attempt to try and sell the idea to another manufacturer. Figure 8.6 summarises and clearly shows the network maps (6-9) and how the network evolves over time.



Map 6: Skunkworks - Informal. Size - 6 actors; Diversity - Internally and Externally Reduced; Openness - Low in relation to Board; Centrality - Low; and Shape - Externally driven. due to ESPRIT.



Map 7: TMS Department - Formalised. Size - 15 actors; Diversity - High Internally and Externally; Openness - High in relation to department but not organisation; Centrality - Low; and Shape - Externally driven by market players.



Map 8: Manufacturing - Formalised. Size - 9 actors; Diversity - Decreasing; Openness - High with Board; Centrality - Low but Boards decision will be crucial; and Shape - Still external orientation to fulfil initial motor-sport orders and Morgan Cars.

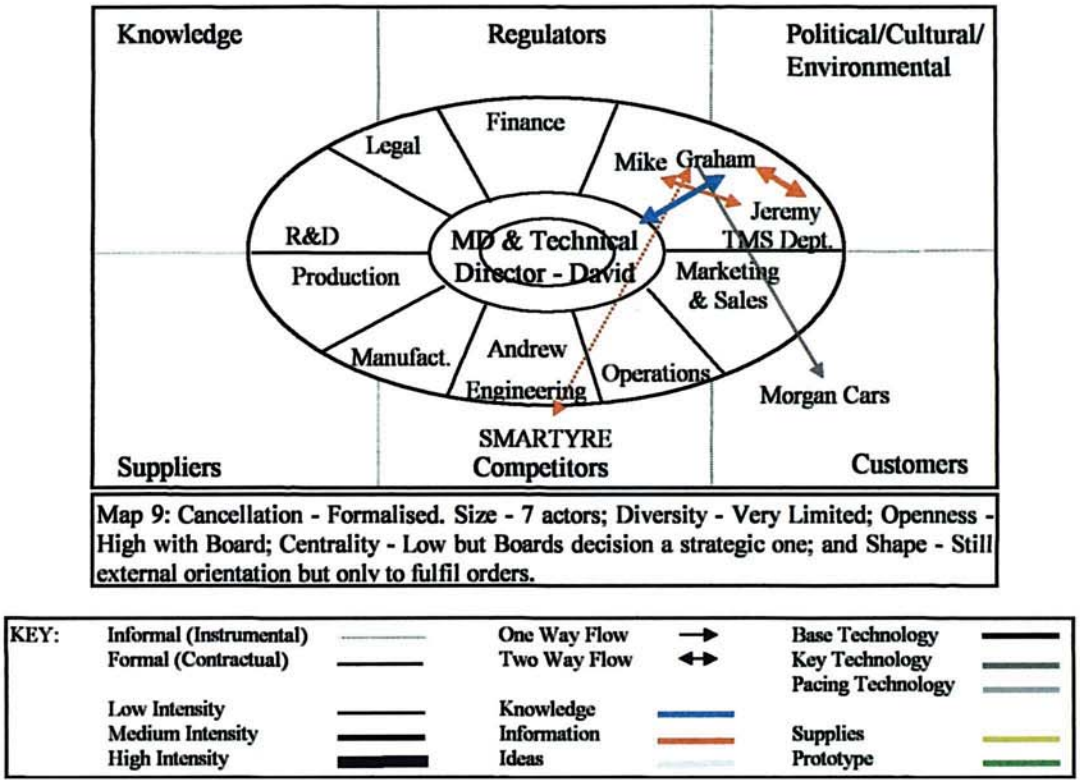


Figure 8.6: Summary of OCL's Strategic Innovation Networks (SINs) 1996-1999

8.3.1 OCL: Accumulated Technological Competencies & Networks

It should be stated that OCL did not have a broad portfolio of R&D expertise. However, the attempt to develop new technologies and competencies into new market areas led to the TMS project and then the TMS. R&D expertise was reduced when the electronics department was disbanded and many potential new electronic domestic products never made it to manufacture. The organisation maintained a wide and valuable range of competencies to meet existing technological competencies and market requirements and this strategic move has changed to the development of existing products and technologies. Certainly, OCL had some highly skilled people as part of the TMS team but with the product proving unsuccessful and failing to make it to market then the majority of these competencies and skills have no value to the current strategic thinking in the company. The removal of an electronics department and isolation of the TMS department from the overall organisation limited the sharing of competencies. The TMS team did have enquiries regarding using the sensor in other application to measure pressure in inaccessible areas such as Nuclear Facilities, Jet Engines. The value of this competence could only be seen if the initial TMS product had realised its potential and been taken up by car manufacturers and tyre manufacturers. Table 8.7

summarises the competencies of the individual actors and transactions, if any, they have with internal, external actors. At the end of the project I asked Graham Kennet what he had learnt from his experience on the TMS project. The key experiences raised where both of benefit to him but also to OCL. A prime example was the development of rapid-prototyping at OCL and solid modelling. Speeding up the development and design of products like the TMS but it may also be of value to cut-out products and especially cut-out systems.

Actor	Relationship	Transaction Content
Andy Derbyshire	**Prod. Develop Engineer**	Knowledge - Development of current project and cut-out competency
Andrew Bromley	**Assistant Electronics Manager**	Electronics knowledge
Mark Guyer	**Product Manager**	Project Management
Graham Kennet	**Project Leader '96-'99** - instrumental tie	Information - Learning about electronics
	Intensity - High	Value - High to support marketing & sales
Paul Martin	**Sales Engineer**	Information - Engineering understanding
	Intensity - High with Graham Kennet but low -medium with team. High with external organisations.	Value - High to develop a potential customer base and contacts
Chas Kilby	**Development Engineer Testing**	Value - High in utility testing, developing collaborating systems
Jeremy Siddons & Mike Holmes	**Electronics**	Transaction - High in terms of electronics knowledge
	Intensity - High in the TMS team but now low throughout OCL due to loss of Electronics department.	Value - High in development of electronic systems and software development (Jeremy Siddons only)
Andrew Phillips	**Manufacturing**	Transaction - Information on manufacturing possibilities
	Intensity - Low to Medium (Likely to increase as the project nears the manufacturing phase)	Value - Low to Medium Utility - Medium to High

Table 8.7: OCL - Accumulated Technological Competencies & Network Variables

8.3.2 OCL: Internal Strategic Cohesion & Networks

At the outset of the development the shape of the network was focused towards knowledge and the input of senior management and the Technical Director was strong. Shape altered in the final stage of the project 1996 onwards when internal relationships increased but saw a positioning of the network within the organisation that limited its links to the rest of the organisation. The team from 1996 was together for at least two years apart from Andrew Phillips and therefore the stability over this period of the network was high. The TMS network may have been considered very 'open' within its department but was 'closed' due to the lack of external links throughout the organisation. Table 8.8a indicates the network is strong and beneficial for the objective of the project. The actors within the TMS network are linked strongly by the TMS. The shape of the internal network has varied over time in terms of its relationships with management and the rest of the organisation. Internal strategic cohesion was highest during the early 1990s period of the project. The diversity of the internal network has slowly increased over the time of the network - this was limited at the start however as the project developed with the change in organisational structure and then actors the diversity and the potential diversity was increased. Centrality of the team reduced over the time of the network. At the start clearly the Technical Director and David Smith agreed the project on the basis of it fitting the company's implicit technological strategy. However, time and changes in strategy saw the project distance itself from the centre.

Actor	Relationship	Transaction Content	Others
TMS network	Reciprocity - Bilateral between team	Activity Support	Shape - internally strategically focused during early period however from '96 onwards this reduced.
	Multiplexity - High	Information/Know How	Diversity - increased over time of the network externally.
			Centrality - strongest from start to mid '90s. After '96 with the change in strategy the TMS no longer fitted the strategy.

Table 8.8a: OCL - Internal Strategic Cohesion and Network Variables

Table 8.8b shows the TMS networks link with the organisation. At the end of the project the TMS's link with the organisation is weak in the sense that there are no direct/formal multiple role relation links with other OCL members. During the early stages of the project however, this was less of the case with the TMS formally structured within the electronics department and with direct links with production, engineering and corporate centre. This was supported by the belief that the technology was not far removed from the company's current competencies. (David Smith, Jan, 98) The diversity of the TMS network and the organisation was high during the early to mid stage of the project. However, the final two years of the project saw a network develop which radically changed in terms of links to other departments and actors within the organisation thus seeing a reduction in the diversity of internal links.

Actor	Relationship	Transaction Content	Others
TMS with OCL	Reciprocity - Unilateral	Information	Shape reduced internal links over time.
	Multiplexity - Low	(changing with sales inclusion)	Diversity - reduction in diversity of internal links over time.
			Centrality - links to centre very formal and then reduce. Near the end very informal and limited.

Table 8.8b: OCL - Internal Strategic Cohesion and Network Variables

Maps 1-7 (Figures 8.1, 8.2 and 8.3) clearly show the reduction in external links within the organisation. The centrality of the network has shifted with the change in strategy and this is most evident by the fact that David Smith only has an informal link with Graham Kennet - *'I don't see David very much with regards the TMS. Although he does sometimes pop in.'*

8.3.3 OCL: Organisational Specialisms & Networks

Table 8.9 summarises the TMS link with OCL. At the start of the project the company was undergoing a change in strategy and was already examining and developing an electronics department. Such technology was believed to be the future development of many of the company's products. The network maps show a clear change from the TMS playing a role in the electronics department and being supported by the developments and understanding in the electronics department. However, with the removal of the electronics department and the creation of a TMS department the TMS project became far removed from the usual activities of OCL. The intensity of the link between the TMS network and OCL has reduced significantly over time. The link has become one of purely progress updates. The shape has gone from being clearly embedded within the organisation to being a department with no fit into the current organisation structure or strategy. The diversity also changes dramatically over the period of the TMS with high internal diversity and low external diversity at the outset as it was new technology so knowledge was important. However, as the network developed with the changes internally to the organisation the internal diversity shifted. The external diversity increased with both knowledge actors and customers playing a role. This was supported by the inclusion of the sales force examining the potential market place for the TMS that was likely to include many firms in OCL's other markets. The TMS team was able to access current customers to seek potential interest and demand.

Actor	Relationship	Transaction Content	Others
TMS link with OCL	Formalisation - Medium	Information - Updates increasing with inclusion of sales.	Shape at start clearly embedded in the organisation however, no longer.
	Intensity - Started High and at final stages is Low - Medium		Diversity -at start high internally, low externally, near the end low internally, high externally.

Table 8.9: OCL - Organisational Specialisms & Network Variables

8.3.4 OCL: External Orientation & Networks

Table 8.10 relates to external orientation and summarises the external linkages made by the individual actors in the TMS department. It provides details on the nature and strength of the link and its value to the TMS project. The number of external actors linked to TMS increased over the duration of the project. The diversity of the external networks was limited at the start of the project although sensibly the company looked to external knowledge to aid them in developing the initial prototype. The SUBS team was very theory, technology and solution orientated with limited customer/market understanding. The failure of the collaboration led to the network still being technology driven, not helped by the ESPRIT Programme that concentrated on financing in this case the development of ASIC technology. The external diversity was limited in relation to customers and potential markets. However, when the network actors changed in 1996 the external orientation and diversity changed. The increase in external actors provided information and knowledge about the potential market but only potential customers existed. The shape of the network shifted over time from focusing on knowledge and the left hand side of the template to a clearer left and right sided shape with the TMS department in the middle. However, these were not formal ties and the stability of the network appeared weak during the final stages of the network with the openness and informality of instrumental ties.

Actor	Relationship	Transaction Content	Others
MD 1990 to 1996	Origin - Salford University and CAMPUS Charitable Trust Mulitplexity - High Reciprocity - Bilateral	Information: Research, products and services. Aims to solve business problems.	Diversity - High with links to over 100 companies potential links to university research departments.
Chas Kilby, Andrew, Andy and Mark	Origin - Link developed with CAMPUS/SUBS. Led to formal collaboration with SUBS team. Multiplexity - Low only two engineers from SUBS. Reciprocity - Bilateral	Information and Knowledge on RF Technology and low power cells	Diversity - limited in relation to OCL/TMS team.
Graham Kennet	Origin - Links through OCL' ties with the automotive industry. Multiplexity - Medium Reciprocity - Bilateral	Information: To stimulate customers and potential sales.	Diversity - High with using trade fairs and conferences to discuss TMS with auto manufacturers and tyre customers and develop links. Intensity greater in Paul Martin's case.
Paul Martin	Origin - Links through OCL' ties with the automotive industry. Multiplexity - High with potential customers. Reciprocity - Bilateral	Information: To stimulate customers and develop potential sales.	Diversity- High with using trade fairs and conferences to discuss TMS with auto manufacturers and tyre customers and develop links.
Chas Kilby	None	None	
Jeremy Siddons	Origin - Links with suppliers for electronics equipment. Multiplexity - Medium Reciprocity - Bilateral	Do provide technical information	
Andrew Phillips	Origin - Links with Motorola Multiplexity - Medium Reciprocity - Unilateral in favour of Andrew	Value: information and know how regarding moulding and companies that may supply materials ect.	Diversity -
Mike Holmes	Origin - Links with RCA due to regulations on RF Transmission and NEXUS for production of PCBs Multiplexity - Low with RCA but Medium with NEXUS Reciprocity - Bilateral	Value - is to get permission to commercially use the RF Transmitter in the UK and then USA. Provide technical information. Value - exchange of information and supply PCBs cheaper than OCL can produce.	Diversity - key external actors but limited diversity as specialists.

Table 8.10: OCL - External Orientation and Network Variables

The TMS relied on the tyre manufacturer getting the new tyre development accepted and automotive firms fitting the tyre. Unfortunately this was not going to be the case until 2001. The external orientation of the project had both assisted the development (University, Suppliers, Customers) as well as limiting its focus (ESPRIT Programme) and ability to meet the market due to its technology focus rather than increasing the market focus until late in the development.

8.3.5 OCL: Management Skills & Networks

The two key individuals in the TMS project were Graham Kennet and Paul Martin. Graham Kennet was connected to a number of projects that kept him in touch with the organisation's specialisms (DC/AC Cutouts) thus leading to a higher degree of multiplexity for him with the overall organisation than with the TMS team. His role as a project manager was highly formalised and success in the management and development of OCL was seen to make him the obvious choice to get a flagging project up and running successfully. Paul Martin's role was one of developing sales contacts and feeding information into Graham Kennet and the team regarding competition and technical information from testing by potential customers. His strength and the reason he was brought onto the project was to manage and develop the potential client base.

Actor	Relationship	Transaction Content
Graham Kennet	Instrumental & affective ties	Information
	Multiplexity - Low with TMS individuals but High with OCL.	To develop strategy and manage TMS
	Formalisation - High	Value - High
Paul Martin	Instrumental & affective ties	Information - Market
	Multiplexity - Low with TMS individuals but High with OCL.	To develop strategy and manage TMS
	Formalisation - Medium	Value - High

Table 8.11: OCL - Management Skills & Network Variables

8.4 OCL SUMMARY

OCL began its technological evolution at the start of the 1990s attempting to access new technologies and competencies that would complement existing business, develop new products, markets and provide major competitive advantage. The TMS unfortunately would appear to have failed to achieve this. The strategy embarked upon in the early nineties was based on forecast that have not materialised as yet although the market has undergone a downturn in the last 2 years (1997-1999) with manufacturing suffering with the strength of the pound hitting exports. The TMS developed on the basis of a particular strategy undertaken but was potentially before its time in terms of customers and markets. There was a heavy reliance by the team in the later stages on market information coming from auto manufacturers and tyre manufacturers. Over the life of the TMS innovation the network Maps 1-7 (Figures 8.1, 8.2 and 8.3) show some very distinct differences. Comparisons highlight the changes in external orientation in terms of multiplexity (role relations). At the start of the project (Maps 1 and 2 - Figure 8.1) OCL was developing internal electronics/sensor competencies/skills by formally linking with the UK University (Map 3 - Figure 8.1). However as the project evolved a greater number of role relations developed externally providing informal but instrumental ties with potential customers and market players. It also shows the change in the TMS innovation network's interaction with the rest of the organisation and therefore the reduction of internal strategic cohesion. When the project began there was strong and formal involvement of the electronics department, other functions in the organisation and the Technical Director (Maps 3, 4 and 5 - Figure 8.1). But as time has gone on (Maps 6 and 7 - Figures 8.2 and 8.3) with strategic changes in the organisation the cohesion between the TMS and OCL was reduced dramatically. Failure was not expected and came down to timing. This was not helped by the lack of early marketing and environmental studies undertaken. However, under Graham Kennet the team concentrated too much on the US market aiming for very large-scale manufacturers like Ford, GM with limited consideration for the middle market such as Morgan Cars that came too late. Maybe a lower premium product would have made the UK and European markets as an add-on sold through the likes of Halfords. However, this was never really considered as an initial market strategy.

8.5 DUFAYLITE DEVELOPMENTS LTD (DDL)

DDL's products and markets are very different from the other cases. However, the organisation utilises manufacturing and production equipment that would not be out of place in the other cases. Traditionally, new products based on the honeycomb technology have not employed the use or acquisition of new technology. Since the development of the fire protection business and construction division there has been very little innovation either utilising the core technology or developing new competencies.

> *'Dufaylite's innovative capacity is limited.............and has been limited by the market potential in the UK which it has traditionally relied on'* (Anthony Wascrop, Jan. 1998).

The most advanced new technology acquired and developed by DDL was a gluing system allowing new packaging to be created. New packaging forms and shapes could be designed and produced in-house to meet market and customer requirements and this provided greater flexibility to the production of honeycomb. The technology provided DDL with a potential competitive advantage over many packaging producers as lighter and recyclable packaging can be produced to compete with polystyrene packaging. The new product required machine development and a strategic change within the firm plus investment of £75,000. The strategic change is in relation to how the products came to market. The product was brought to market by licensing the machines to foreign markets. Companies licensing the technology were also supplied with the honeycomb paper insert for the board. This secured the competency of the honeycomb production and also got DDL's core product into overseas markets whilst reducing the bulk of shipping. Folded paper honeycomb reduces shipping volume by up to 300% and thus increases margin.

8.6 THE INFORMATION TECHNOLOGY PROJECT

On joining DDL, Anthony Wascrop - Managing Director found that the information available to him regarding such developments discussed in the previous section as well as strategic planning, business planning, financial planning, logistics as well as sales and marketing was almost non-existent. An example of this was the development of the Business Plan which was left up to the Accounts Manager and Financial Director with no consultation with the rest of the organisation. Information relating to the likes of stocks was in the hands of the Operations Director with no link to the accounts and financial departments. He had difficulty gathering information on sales and markets and tracking new developments internally and externally. There was no central development of information and no formalised procedures to ensure that information was documented reduced the value to decision makers. An example of this was the

> *'.......up till now it has been a very poor internal communications between individuals and divisions/functions........a lack of follow up on advertising campaigns in previous years Dufaylite has seen £120000 of advertising enquiries sitting in a box with no action being taken by any division'* (Mike Burnell, Dec. 1998).

At the start of 1998 the company decided to examine its internal processes and where possible innovate internal processes to support efficiency in manufacturing, production and marketing. The project began with an examination of its information technology capabilities. The delay from 1995 to 1998 was down to the difficulty in getting the likes of the Financial Director to accept the possibility of change, to examine processes and to try to develop news ways of working through new IT systems. The requirements of the project:

- to integrate individual systems such as business planning and financial planning.
- to encourage communication through the IT system
- link information across the organisation so all directors and managers have access to up to data information as well as production, engineering and sales information
- to improve and be more market focused both in the UK but more so in Europe with ever changing environmental issues and regulations
- to remove the old mentality of Directors and senior managers spending days preparing reports for Board meetings by the increasing use of IT in the company *'The new project aims to remove this need from the Board meetings, providing more time for making decisions on company development and investment opportunities'* (Anthony Wascrop, Jan. 1998).

Actor	Position/Relationship
Anthony Wascrop	**Managing Director** - instrumental tie
Mike Burnell	**Project Manager**
Andy Wick	**Operations Director**
Internal Department Managers	**Department/Function Managers**

Table 8.12: DDL - Identified Internal Actors and Positions

External Actor & Type	Template Position	Internal Actors	Map
SuperOffice	Suppliers	Mike Burnell	Map 2 & 3
Pegasus	Suppliers	Mike Burnell	Map 4
Opera	Suppliers	Mike Burnell	Map 5

Table 8.13: DDL - External Relationships by Collected Network Data

Table 8.12 identifies the internal actors involved in the network and Table 8.13 identifies the external relationships. Those involved formally in the project at the start were Mike Burnell - Accounts Manager who was the project co-ordinator and involved in examining the systems along with Andy Wick - Operations Director, and finally the Managing Director - Anthony Wascrop because of his sales and marketing expertise. These actors are clearly mapped on Map 1 (Figure 8.7 details in Table 8.14). The map shows that the network includes only the key decision-makers who will decide the developments and evolution of the project in relation to the available skills, abilities and knowledge within the organisation. Mike Burnell's role was key given his IT understanding and his knowledge of the organisations ability to ultimately use a new IT system developed to aid, support and improve operations. The Operations Director's input assisted in the identification of key individuals and the decision on which areas of the organisation could benefit and cope with the complexity of the changes. All three actors had input to the project plan including which individuals would be formally involved. Map 1 clearly shows that at this early stage the intensity of integration is high and a formal relationship was developing.

Network 1 Dimensions	The Network
Size	The network at this stage was at it's smallest. Three internal actors and two groups of external actors. 5 actors in total.
Diversity	The internal actors are not as diverse as they might have been. Only the Chairman, Operations Director and Accounts Manager make up the internal network. Diversity is limited due to the problems addressed with particular Directors.
Openness	The openness of the network is also limited at this stage due to exclusion of particular directors and limited skills in areas such as marketing at this stage.
Centrality	A major element and the driver of the project was the Chairman. The project was centrally focused and the intention is for it to aid strategy.
Shape	The shape indicates the limited inclusion of actors and identifies the external links. The external links focus on suppliers although these are providing information and knowledge which may be applied to the organisation to meet the project aims/objectives/strategy.

Table 8.14: DDL - Network Map 1 Dimensions and Detail

The team identified division managers to champion the project within their areas. This was important because *'...........there is still a 60s mentality in the company which is changing but change is often slow and difficult'* (Anthony Wascrop, Jan. 1998).

Before the full team was identified Mike Burnell examined the software market for IT solutions to DDL's problems. He examined software that could operate across divisional boundaries providing global as well as restricted access to users. Map 1 therefore shows that external influences were an important element of the decision making process at the start of the project. The company briefly considered the idea of developing software in-house but time and man-hours put pay to that. The packages had to allow the firm to integrate its different information systems; and develop long term with changes in company structure. As of the 19th January 1998 the company began running trials of a software package known as SuperOffice, the trial being a free 30 day trial offering advice on linking systems and training if the decision to develop the SuperOffice software is made. Therefore, as shown in Map 2 (Figure 8.8 details in Table 8.15), the company behind the software, during the trial, came and talked with the divisional managers (champions) as well as operations, finance, engineering and production managers. This communication link allowed the supplier to get a feel for what might be achieved with the software. The intensity of the link between the software supplier and the organisation is strongest at the point with Mike Burnell. The links with the champions highlights the importance placed by the team on the champions to get the project off the ground in their product areas. The other potential influence on the project was the owner of DDL who signs off expenses and investments. They have allowed DDL to generate and develop its own business providing turnover is rising - *'We have a good relationship and meetings are quarterly although the Chairman and I talk by phone weekly'* (Anthony Wascrop, Jan. 1998).

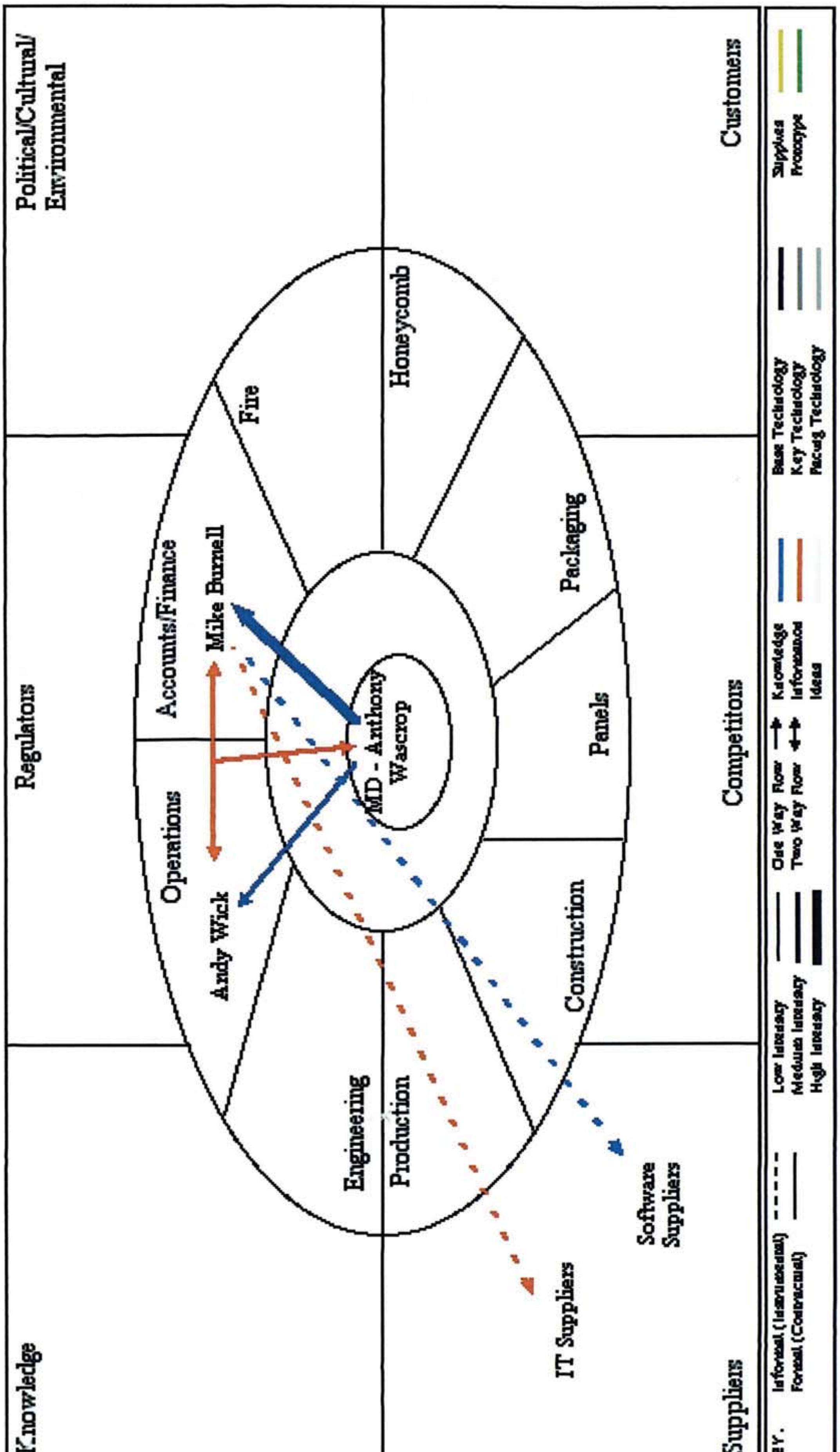


Figure 8.7: DDL Map 1

Network 2 Dimensions	The Network
Size	The network increased in size due to the inclusion of champions and the trial of SuperOffice. The network formally included 10 actors.
Diversity	The diversity of the network increased dramatically with the inclusion of individual champions - one from each division. Therefore, the trial was expected and did supply very different perspectives on the use of SuperOffice.
Openness	Openness was limited as there was no formal discussions between individual champions as a group.
Centrality	Ultimately the trial was evaluated by Mike Burnell and Anthony Wascrop - with Anthony Wascrop as Chairman making the ultimate decision. This was based on benefits to the individual divisions as well as to supplying the Chairman with real-time financial, sales data ect.
Shape	The shape indicates a focus on the software supplier and the use of champions in the divisions. Each champion had a key role to play in the decision to accept the software. Therefore, there were clear formal links between Mike Burnell and the Champions. Initially this was the supply of the Software which at the end of the trial led to transaction of information on the trial.

Table 8.15: DDL - Network Map 2 Dimensions and Detail

The external actors on the project were the software providers with whom there was no formal agreement. Map 2 shows the relationship as a dotted line clearly signifying an informal relationship with no contractual agreements. DDL held the cards in this agreement and if the trial was not satisfactory and the software and its development did not meet the company's needs then no agreement would have been entered.

The individuals involved in the project were picked not because they were specialists in the field as this project is somewhat of an unknown given the history and lack of IT in DDL.

> *'....the individuals are key people in the day to day running of the company and are arguably best placed to decide what information is required and how best it may be achieved'* (Anthony Wascrop, Jan. 1998).

Their involvement was not full time as individuals had other tasks, and day to day projects. The person closest to being full time on the project was Mike Burnell the project co-ordinator. Given the size of the company and its reasonably small premises the individuals involved were never out of reach and there is therefore a great deal of informal communications, that is communication outside the formal process of set meetings. Anthony Wascrop's office is right next door to Mike Burnell's. Formal meetings were held regularly in the sense that all the individuals formally involved in the project met at the monthly Board meetings. Current information that could be produced on different divisions and functions was used to form the basis of the meetings.

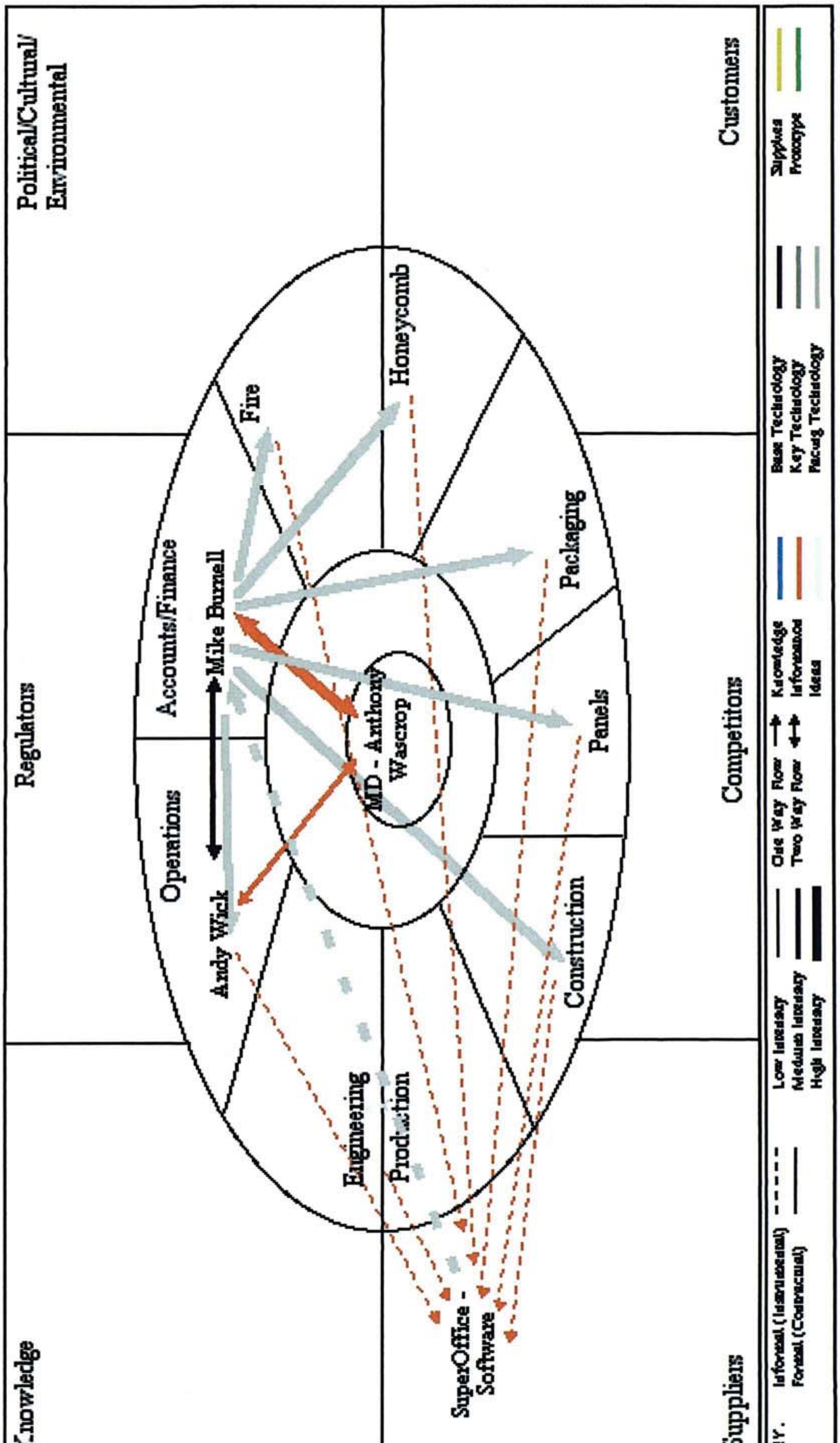


Figure 8.8: DDL Map 2

'At the end of 1998 the business was not exactly setting the world alight.' (Mike Burnell, Dec. 1998) Therefore, the business needs discussed with Anthony Wascrop early in the year were finally considered and made a part of the brief of the new marketing manager. The marketing manager began looking at packaging, new market segments and how the products and the business as a whole should be positioned in the market place. This change in the organisation altered the informal structure of the organisation but also more importantly the emphasis of the organisation from sales and accounts to marketing working in tandem. Benefits were seen to develop over time and the project was expected to be ever evolving.

Network 3 Dimensions	The Network
Size	The network size for this new development stayed the same.
Diversity	The diversity of inputs to inform the central team and Mike Burnell of how the trial went was broad. Diversity high with inclusion of all functions.
Openness	Openness was still limited in relation to departments linking and relating to one another around this project.
Centrality	The information being supplied on the trial was directed at Mike Burnell as the Project Leader and as part of the decision making process this information was fed back to Anthony Wascrop (Chairman)
Shape	The shape and relationships within the network indicate the focus was on Mike Burnell to take on board the trial information and make sense of it.

Table 8.16: DDL - Network Map 3 Dimensions and Detail

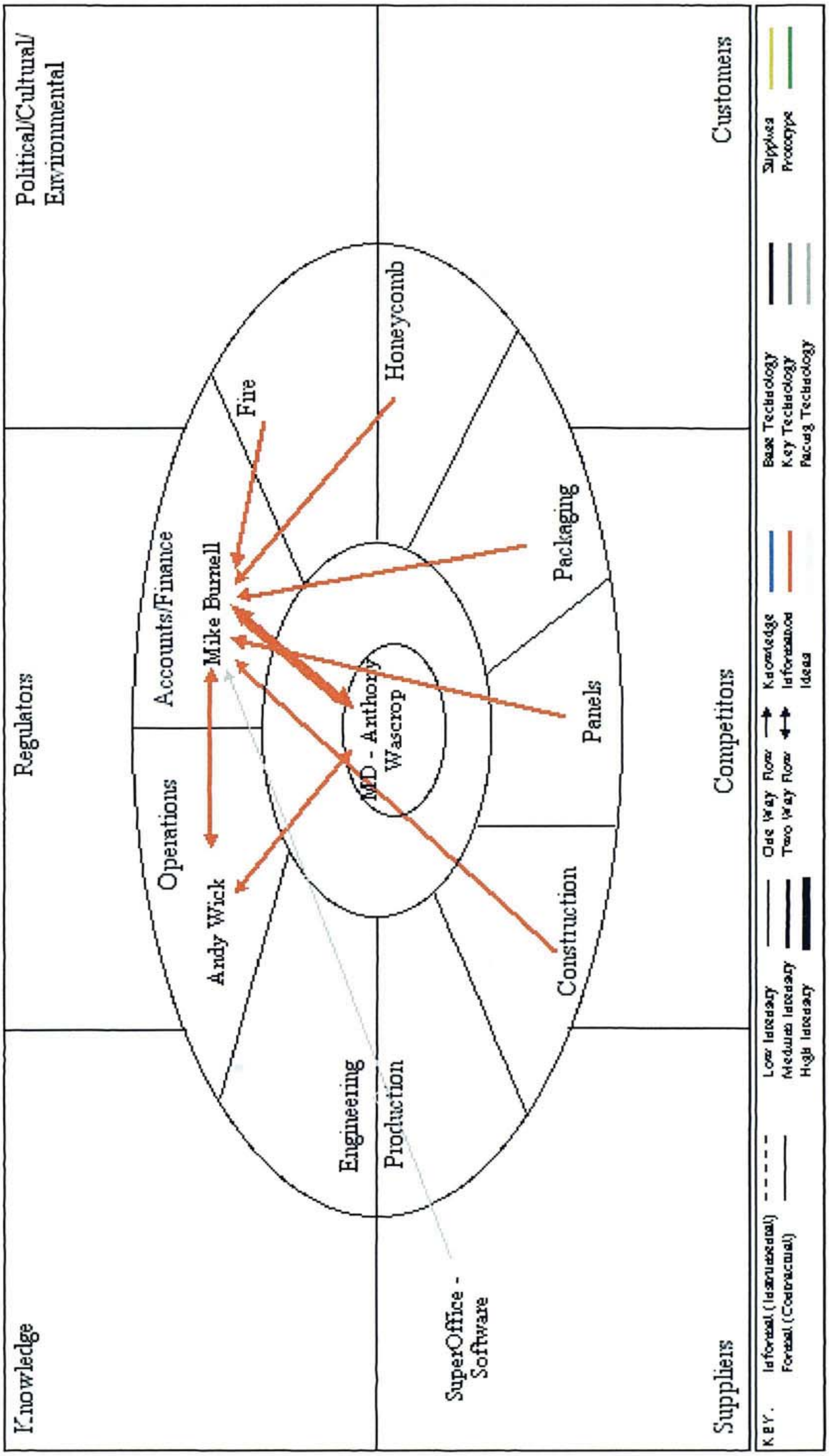


Figure 8.9: DDL Map 3

At the end of the 30 day trial each of the champions that tested the SuperOffice package were asked for their reactions and views on the potential of the package. Questions included: in what ways did or could it help your area?; and where was it limited? The main advantage was centralising all information and data throughout the organisation that could be made available in real time to anyone that required it (see Map 3 - Figure 8.9 details in Table 8.16). The introduction of the SuperOffice allowed sales lists and stock lists to be shared via internal email and internal access via the IT system. Mike Burnell bought in a new piece of accounting and sales software to work in relation to the SuperOffice system and future software. The link with the supplier was purely to supply the software with limited interaction (see Map 4 - Figure 8.10 details in Table 8.17) unlike the SuperOffice trial and discussions to develop the system.

Network 4 Dimensions	The Network
Size	**The network size for this new development stayed the same. The network continues to have formally 10 actors.**
Diversity	**The diversity reduced, although the same actors continued to have some input and impact. However, the accounting software meant that greater time was paid to the accounts department.**
Openness	**Openness was limited although each champion and department was aware of the changes in accounts and that at the current time only certain individuals would have access. Although, some relevant accounting information was available to all.**
Centrality	**The accounts/financial software was viewed to benefit the senior decision-makers in the organisation more than the individual departments. Again meeting the main concern of the Chairman when he joined DDL. It allowed direct access to strategic and marketing information.**
Shape	**The shape and relationships within the network shows that the focus was on Accounts and Finance. The link between other divisions was reduced in terms of intensity. The balance shifted in this case.**

Table 8.17: DDL - Network Map 4 Dimensions and Detail

The link with Pegasus was simply as a supplier of the software. Mike Burnell had the task of integrating the software with the SuperOffice. This stage of the network involved the software being applied in a specific way to provide the Finance Department with access to data more readily and speedily. The main link was with the Accounts and Finance department team, of which Mike Burnell is a member, with the main development work involving the setting up of reports and financial sheets that could be pulled off the system by those with the correct login and password. At this point the actors included Mike Burnell as the administrator, the Finance

Director and team and the Chairman. The information was available from any PC within the organisation providing access to stocks, inventory, sales, and invoicing.

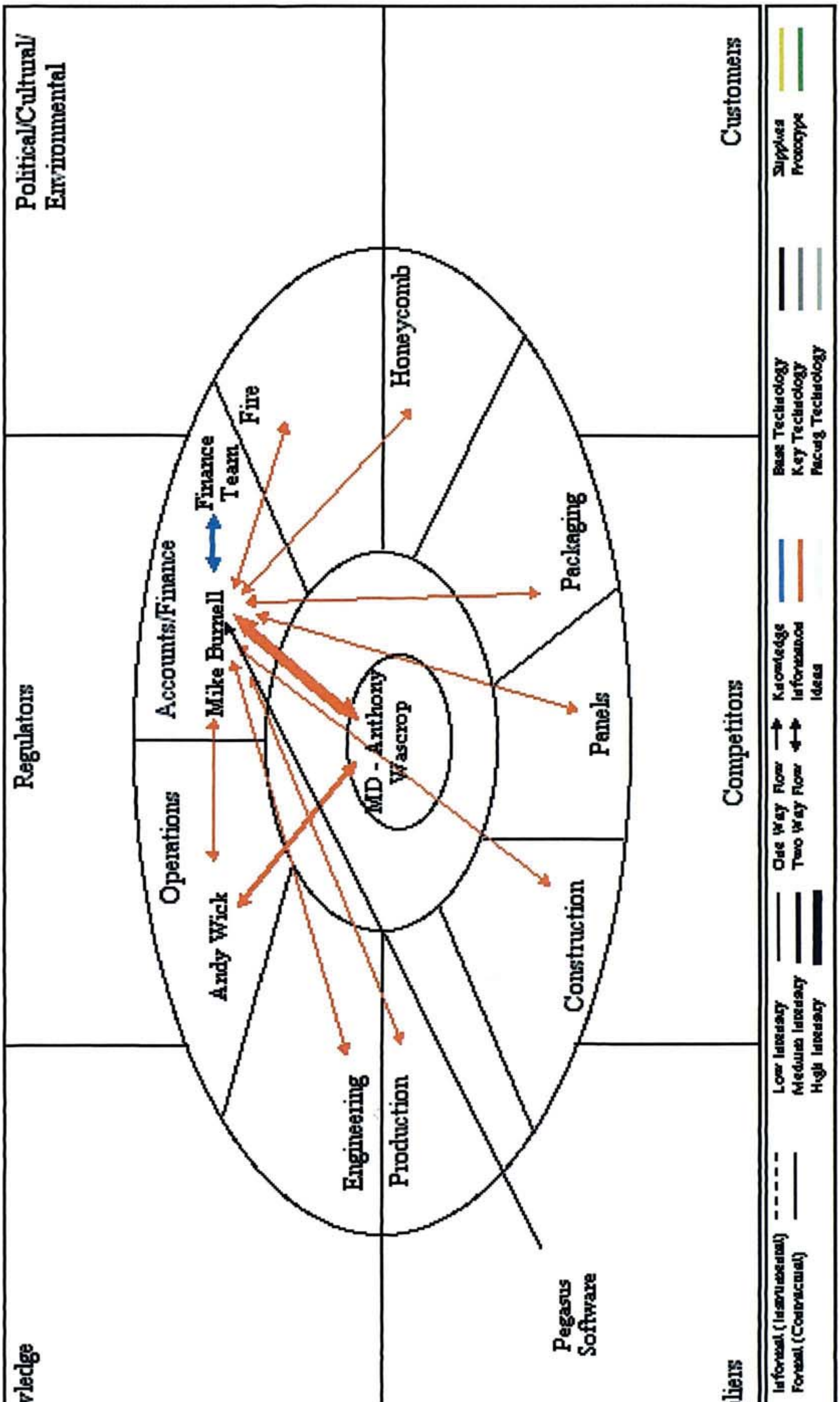


Figure 8.10: DDL Map 4

Map 5 (Figure 8.11 details in Table 8.18) shows the inclusion of a further external actor to supply the Opera System. The system was examined by Mike Burnell during the autumn of 1998 in order to view its relevance to the project and to provide production and engineering with an interface to develop job costings automatically which will update stocks and inventory when a job is complete. The plan was to connect to the new accounting system (Pegasus accounting). When an order is made by a customer the system provided information as to whether the company can deliver it and the delivery date plus it provided job time calculations and allowed management access to stock levels. This removed the time wasted by employees in putting together costings manually and job orders on the back of enquiries. Often enquiries were not followed up due to the time constraints. The system speeded up the process reducing overheads, keeping overtime levels down and driving volume up. The key actors here were engineering, production and operations. These impacted on the divisions but this was expected to be limited hence the reduced intensity of link between Mike Burnell and the divisions. However, during this evaluation period the intensity of link between Mike Burnell and engineering, production and operations was high and involved an examination of current processes operation. Such a relationship involved knowledge transactions.

Network 5 Dimensions	The Network
Size	**The network size for this new development continued to stay the same. The network continues to have formally 10 actors.**
Diversity	**The diversity was reduced, although the same actors continue to have some input and impact. There was increased diversity in relation to Mike Burnell with the intensity of links with Production, Engineering and Operations increased.**
Openness	**Openness continued to be limited.**
Centrality	**Centrality was still high. The Operations Director played a key role in the knowledge transfer and this impacted on the decisions made by Mike Burnell and the Chairman.**
Shape	**The shape of the network changed little from previous networks. However the key relationships shifted to operations rather than divisions/departments.**

Table 8.18: DDL - Network Map 5 Dimensions and Detail

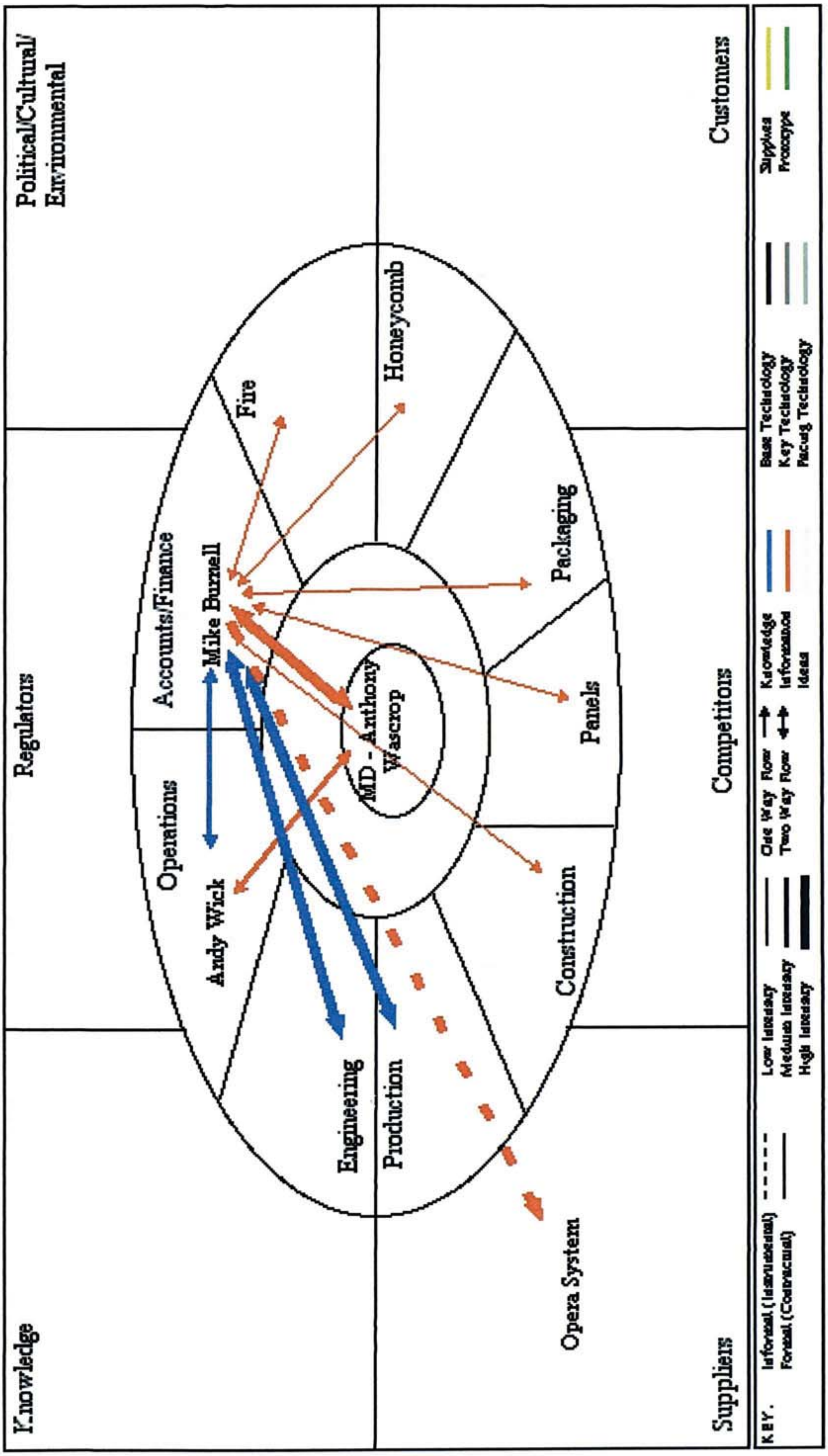
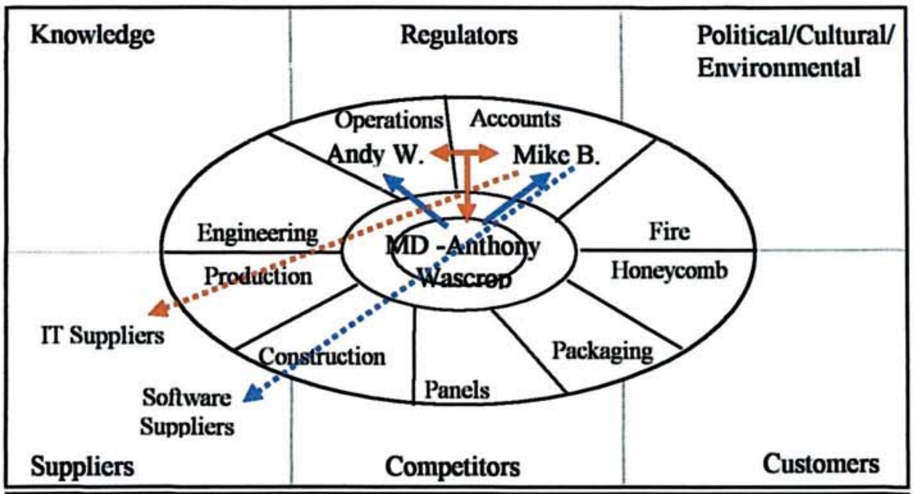


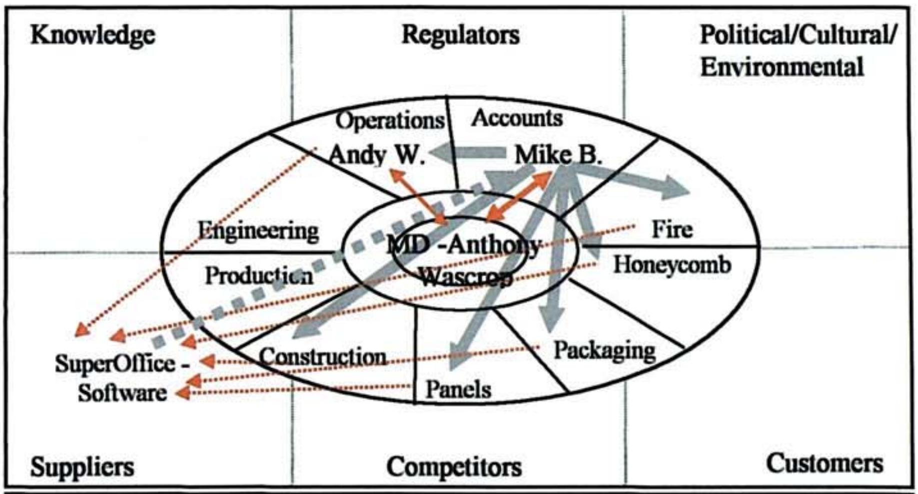
Figure 8.11: DDL Map 5

8.7 DDL: NETWORK SUMMARY & FRAMEWORK ANALYSIS

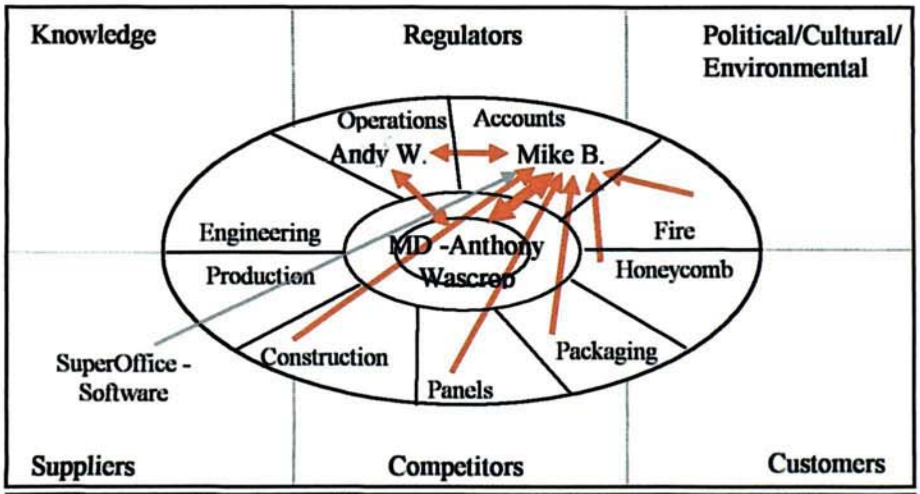
Maps 1,2,3,4 & 5 (Figures 8.7, 8.8, 8.9, 8.10 and 8.11) show that the networks at DDL, to develop internal IT systems, were stable as they changed little over the life of the project. The basic network involving Andy Wick, Mike Burnell and Anthony Wascrop existed throughout the project and the internal actors utilised to examine areas of the organisation and to develop the project in relation to those areas remained the same. From Maps 2-5 (Figures 8.8, 8.9, 810 and 8.11) there was a definite increase in the number of actors from the centrally orientated network in Map 1 (Figure 8.7). Internal diversity of actors was stable across the network maps and provided Mike Burnell with the opportunity to develop ideas (Map 2 - Figure 8.8) and then to gain feedback and information from those actors (Map 3 - Figure 8.9) in order to design and develop the IT and software systems. However as the project progressed the external diversity changed to meet particular needs of the project at that time. The core of the formalised network was highly centralised within the formal hierarchy of DDL (Maps 1-5) with Anthony Wascrop taking a relatively hands on approach to the project working closely with Mike Burnell. The shape of the networks although becoming increasingly dense as the network develops internally stays relatively unchanged throughout except for the external supplier relationships. The shape indicates and supports the fact that the network was internally driven via the core network of three (Map 1 - Figure 8.7). Mike Burnell had the role of the boundary spanner with the suppliers and the internal actors in the various departments. At this organisational level the networks show a definite centrality and an internalisation of the project. This is quite similar to the DFM case however the original idea and push for the project came from Anthony Wascrop (Managing Director). He aimed to create a stronger marketing function and to understand and centralise information available across the company to push the individual businesses in current markets and in new markets. The entire network maps (1-5) for DDL are summarised in Figure 8.12.



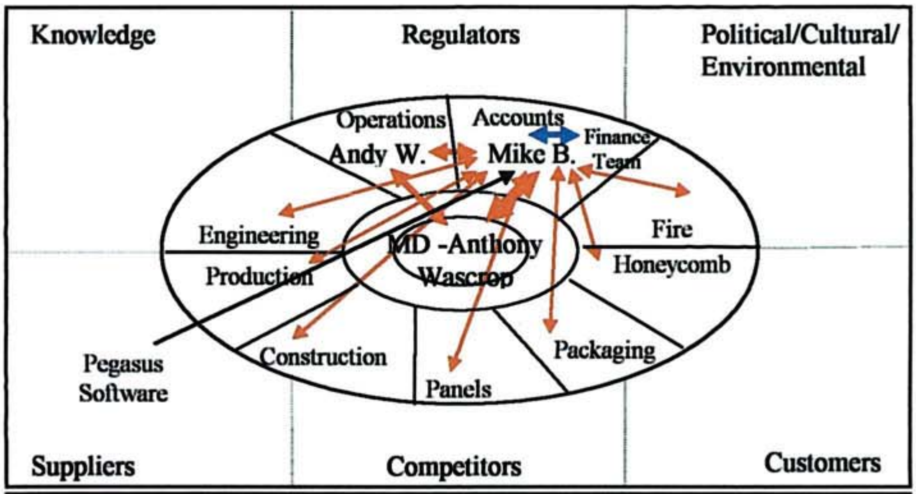
Map 1: Internal Feasibility Network: Size - 3 internal actors plus informal external actors; Diversity - Medium ; Openness - High in relation to Board; Centrality - High; and Shape - internal orientation at this stage to identify what is needed.



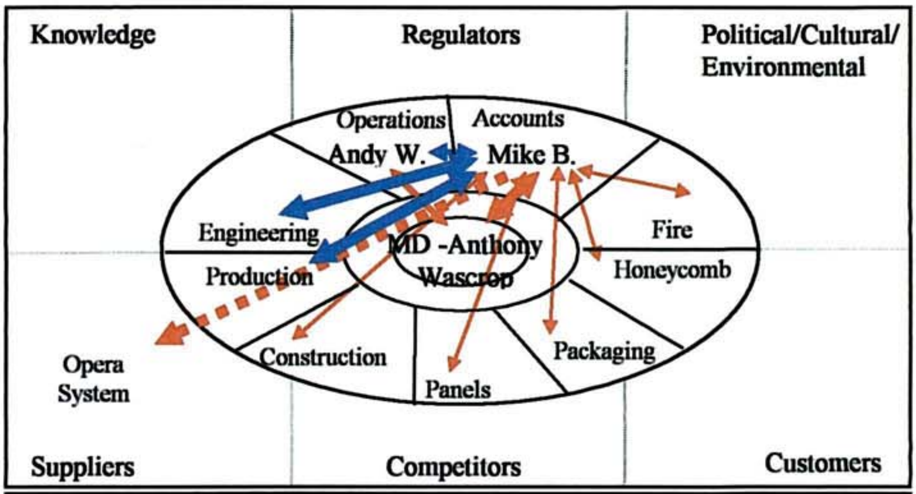
Map 2: Supplier Network: Size - 8 internal actors plus informal external actors; Diversity - High internally ; Openness - High in relation to Board; Centrality - High; and Shape - internal orientation to test software.



Map 3: Champion Network: Size - 8 internal actors plus formal external actors; Diversity - High; Openness - High in relation to Mike; Centrality - High; and Shape - internal orientation at this stage to agree system benefits.



Map 4: Supplier Network: Size - 11 internal actors plus formal supplier; Diversity - High internally; Openness - High in relation to Mike; Centrality - High; and Shape - internal orientation.



Map 5: Supplier Network: Size - 11 internal actors plus formal supplier; Diversity - medium internally; Openness - High in relation to Mike; Centrality - High; and Shape - internal orientation however more knowledge based in relation to prod. and engin.

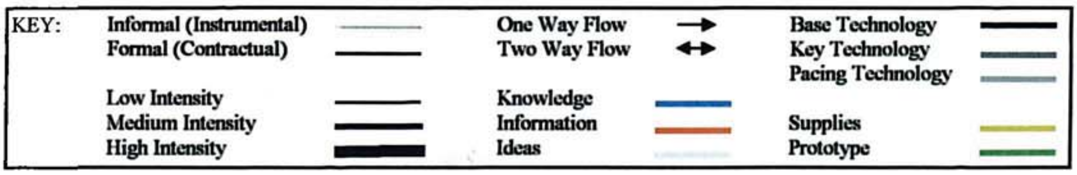


Figure 8.12: Summary of DDL's Strategic Innovation Networks (SINs)

8.7.1 DDL: Accumulated Technological Competencies & Networks

Core competencies consist of a body of technological expertise and the organisational capacity to deploy that expertise effectively. These competencies are then employed in creating core products which are used in the production of the final products (Coombs, 1996). The core competence of DDL is the paper honeycomb process that requires capabilities, honeycomb expansion, paper bonding, cutting paper block and handling paper. This gives rise to the core product of the company that is the paper honeycomb blocks that go into all the product divisions discussed earlier. Examining the core competencies of DDL highlights a limited number making the examination of overlaps and synergies between products (Coombs, 1996) easy to view. Because the same technology is used throughout the organisation means that the most likely new products/innovations to be developed will be based on the honeycomb. The technology has been around for over 40 years and has always been at risk from a replacement by new materials (possibly biotech and plastics). This competence has little direct value to the IT project at its outset. Table 8.19 summarises the network variables of each actor in relation to accumulating technological competence.

Actor	Relationship	Transaction Content	Other
Mike Burnell	**Project Leader** - instrumental tie	Information - Systems Understanding	
	Intensity - Medium to High with all actors	Value - High to drive project, support team/users and bridge team with supplier.	
Andy	**Operations Manager**	Information - Organisational Process knowledge	
	Intensity - High with Mike Burnell and Chairman at start of project although reduces. This intensity increase again in the most recent development.	Value - High to provide information and knowledge on processes	
Chairman	**Chairman** - Decision Maker	Decision - Making	
	Intensity - High with Mike Burnell throughout project and medium with operations director/manager.	Value - High in relation to marketing requirements and achieving the project.	
Champions	**Divisional/Department Managers**	Information and Process Knowledge	Openness
	Intensity - High during SuperOffice trial and Medium to Low during other software developments	Value - High, as their knowledge has to be turned into software solutions that can be shared and can inform individuals across the organisation. Also information must be of value in relation to the strategic decision makers.	This is an important element here. The champions need to be open and pass on their knowledge about the software to individuals in the departments.

Table 8.19: DDL - Accumulated Technological Competencies & Network Variables

Anthony Wascrop (Jan. 1998) felt that *'IT competencies are limited within the company'*. However, Mike Burnell was the one actor internally who had experience of Information

Technology and software development - although limited. It was identified that Mike Burnell did not have the knowledge of organisational processes and systems in different departments. Hence, the Operations Director was formally included in the team to examine the potential for undertaking and developing a new IT system that would meet the particular information needs of the Chairman as well as the business. As the network developed the project took on a new guise to include champions within departments. The point was to test software packages in the department/divisional areas so that the actors with relevant knowledge for particular areas could examine and react to the software in terms of value, benefits and problems. The champions knowledge was key to taking the project forward and making sure that the changes were accepted by the departments as a whole.

8.7.2 DDL: Internal Strategic Cohesion & Networks

The factor became a key element in the strategic management of the project and technology at DDL. The project was given the go ahead by Anthony Wascrop due to its strategic implications for DDL at a competitive level but also at a decision making level.

> *'It was clear to me that internal information was not being used to inform the strategic decision making process'* (Anthony Wascrop, Jan. 1998).

Actor	Relationship	Transaction Content	Others
Project Team	Reciprocity - Bilateral between team	Activity Support	High Diversity
	Multiplexity - Low except in relation to the Operations Director who has links throughout the organisation.	Information/Know How	Shape - Internally Focused
			Centrality is high with a major influence throughout being the Chairman

Table 8.20a: DDL - Internal Strategic Cohesion and Network Variables

The knowledge and information held by individuals within departments had proved difficult to access. The project aimed to access this information and knowledge in order to develop the system software in order that the information becomes accessible. Therefore, internal cohesion was developed through the network by creating the champions role from around the organisation. In doing so the network linked directly to Mike Burnell and Anthony Wascrop. The network maps (Maps 2, 3,4, and 5 - Figures 8.8, 8.9, 8.10 and 8.11) show the limited external orientation of the project and it was the internal orientation that was key to developing the strategic value of the project and the developed software. The internal strategic cohesion supported the diversity of actors (Table 8.20b) within the network and the shape of the network. The network was internally focused and spread across the organisations functional boundaries.

Actor	Relationship	Transaction Content	Others
Project Team with Board	Reciprocity - Bilateral	Information	High Diversity
	Multiplexity - Low at start but increases over time with the inclusion and links to champions.	Knowledge and ideas	Internally Focused
			Centrality High- The chairman plays a key role in the project especially in the decisions on its aims and objectives.

Table 8.20b: DDL - Internal Strategic Cohesion and Network Variables

8.7.3 DDL: Organisational Specialisms & Networks

The company has one specialism and that is the production of the patented Honeycomb. The organisation operates to produce this in varying forms to meet particular market needs. The project network was heavily embedded in the organisation and the information and process knowledge gathered and used for the software development was expected to be, and was seen to be, related to the production of Honeycomb and the sales to customers. Dodgson and Rothwell (1991) identify openness as a key element to organisational specialism. However, in the network maps and the analysis of the network dimensions (Table 8.21), openness was limited in terms of links between divisions and departments.

Actor	Relationship	Transaction Content	Other
System Team link with Company	Formalisation - High	Information - and Training Knowledge	Internally Focused - Shape
	Intensity - High		High to Medium Diversity

Table 8.21: DDL - Organisational Specialisms & Network Variables

The relationships are formalised between Mike Burnell and the champions. The knowledge and information being extracted and turned into procedures that can be used to develop the software system did rely on explicit knowledge being provided. But the diversity of actors was medium to high throughout the project lending itself to the development of an organisation specific piece of software.

8.7.4 DDL: External Orientation & Networks

The external orientation of the project was limited in relation to the project and the network. Although, relationships were developed with software suppliers offering software solutions, advice and help for the company. No vendor ratings were undertaken to examine other possibilities for developing the system externally. This is not to say they should have but further opportunities may have been accessed. However, the way the project developed has seen the majority of aims and objectives being met. This show that a firm with limited resources can undertake a project without financially bankrupting itself by engaging in lengthy supplier analysis and even the inclusion of consultants. This is risky in one sense but the cost of such a project of this nature can be high (see DFM case study). Table 8.22 summarises the external orientation of the project.

Actor	Relationship	Transaction Content	Other
Mike Burnell	Software Suppliers Multiplexity - High with SuperOffice as they linked up with Champions. Low with other providers. Reciprocity - Bilateral in the case of SuperOffice but Unilateral in two other cases.	Information and Knowledge plus base software technology in case of SuperOffice. Software technology in case of Pegasus and Opera.	Diversity - In terms of external orientation this is low in relation to the project.

Table 8.22: DDL - External Orientation and Network Variables

DDL has taken a different external orientation to attack its information problems using readily available software technology. The reason this may have been possible for DDL is the fact that they have not decided to examine processes directly and adjust and re-organise. If they had this may have required software that was more tailor-made for the organisation in that situation. The external orientation of the network has remained relatively stable and the diversity has come in the software supplied. However, there appeared to be little consideration of a broad number of suppliers. All software supplied could be integrated to share data and this was a key defining point in the choice of suppliers by Mike Burnell and the network.

8.7.5 DDL: Management Skills & Networks

There are three key areas of management related to the project. First is the direct management of the project, second is the management of the project in relation to strategy and thirdly is the marketing and management of project at divisional/departmental level. Mike Burnell skills are firmly based in accounts however because of his role in accounts all individuals in the organisation had dealt with him at some level therefore the multiplexity was high to start with. As project leader he would be a face that people knew. His skills were limited but his knowledge of the use of software in accounting and information gathering was second to none in the organisation. Therefore, he had the relevant knowledge of how to approach and utilise technology.

Actor	Relationship	Transaction Content
Mike Burnell	Instrumental & affective ties	Information & Knowledge - Project
	Multiplexity - High with team individuals and High with champions.	Manage and formalise the project and develop system
	Formalisation - High	Value - High
Chairman	Instrumental & affective ties	Information - Strategic & Company
	Multiplexity - High with team individuals, and champions.	Manage and formalise the project
	Formalisation - High	Value - High
Champions	Affective ties	Knowledge and Information about Departments also to champion idea/software to each department
	Multiplexity - High within departments	To provide knowledge and information about department information processes and information needed and of value to other departments and strategic decision-makers.
	Formalisation - High within core team	Value - High although this varies during network development over time.

Table 8.23: DDL - Management Skills & Network Variables

Anthony Wascrop was the most influential individual in relation to getting the project up and running. This was clearly shown on Map 1 (Figure 8.7). His influence was key to getting the Operation Director involved and Mike Burnell. During the project he continued to supply information as the software developed on the types of spreadsheets and data he required to make decisions and this was supported by the champions to provide that information. The champions were vital to the success and speed of the project - '*Without them the project could have taken much longer and may not have succeeded in some areas.*' (Mike Burnell, May 1999) They provide a link between divisions/functions and Mike Burnell. As the drivers of the project they assisted in moving the project forward. By having the champions using and seeming to develop the software means that the change is somewhat easier for the champion and the individual actors in their area. They are in control of how the software is installed and what it ultimately can do. Table 8.23 summarises the management relationships and transactions.

8.8 DDL SUMMARY

The network approach taken at DDL involves three key elements: centrality, competence and operational understanding and knowledge. It is around the core central network that the rest of the network interacts and operates. Prior to the start of the project, as has been discussed in the case, there was limited communication between departments and functions. The project and its network, although not linking departments directly and making them communicate, means that through the use of the IT systems and software business managers can access information directly from other departmental and business areas. This was made accessible to the Board to strengthen the company's internal strategic cohesion in terms of information flowing from source to decision-makers. To ensure the project accessed the right information and developed solutions to support information gathering and analysis in each business area was the role of Mike Burnell. He acted as the boundary spanner between external suppliers and internal actors. External orientation was generally quite limited in relation to choosing suppliers for software solutions. There was no major vendor rating procedure undertaken. The examination was left to Mike Burnell because of his understanding, all-be-it limited, of office software and accounts packages. However, for the requirements and purposes of the project a large vendor rating was not necessary. The project intended to provide procedures to enter and store information in different areas of the business and then to provide the means to gather that information together in order to make decisions in relation to marketing and sales. Therefore, the project was embedded within the organisation and aimed to pull together organisational specialisms in order to centralise those specialisms to support the organisation and its business. The company's strong competence and product has a number of opportunities available to it to maximise its market potential due to its environmental benefits. The system could be used to develop marketing strategies that could lead to incremental innovations by working more closely with external companies. The project potentially provides a better understanding of the organisation for the decision-makers and will inform the marketing department. Therefore the processes are in place to capitalise on opportunities with good marketing and sales.

8.9 WANDSWORTH ELECTRICAL LTD (WEL)

As discussed in Chapter 6 from mid 1990 WEL managers were aware that its new product development processes were not successful. This was most noticeable in terms of WEL's development of markets, its range of competencies and technologies to create competitive products. The appointment of a new MD Richard Mokett at the beginning of 1998 coincided with the setting up of a new product development committee (NPD). The purpose of this new NPD Committee was:

> *'.....to examine, develop and monitor new innovations, ideas and developments with the company - with the possibility of looking at new markets, new technologies and therefore new product areas providing they were within Wandsworth's competences and capabilities'* (Gary Stevens, Nov. 1997).

8.10 NEW PRODUCT DEVELOPMENT (NPD) COMMITTEE

The internal actors and external actors involved in the networks developed in WEL over the life of the project are identified in Table 8.24 and 8.25.

Actor	Position/Relationship
Richard Mokett	**Managing Director**
Gary Stevens	**Marketing Manager**
Graham Massey	**Engineering Director**
Richard Wooler	**Technical Manager**
Gerry Thornton	**Materials Manager**
Graham Colburn	**Sheet Metal Manager**

Table 8.24: WEL - Identified Internal Actors and Positions

External Actor & Type	Template Position	Internal Actors	Map
Philips Electronics Ltd	Competitor	Graham Massey	Map 3
Philips Electronics Ltd	Competitor	Richard Wooler	Map 4, 5
Philips Electronics Ltd	Competitor	Gary Stevens	Map 3
Radio Communication Association	Regulatory	NPD Committee	Map 4, 5
Age Concern and Aid Caller	Supplier	NPD Committee	Map 4, 5
Home Office	Government	Richard Mokett	Map 3, 4, 5

Table 8.25: WEL - External Relationships by Collected Network Data

Richard Mokett's initial plan developed from the meetings with Graham Massey and Gary Stevens. The discussions involved the sharing of information between the two actors relating to business, markets, technical skills, products and existing projects. What was most important about the initial meetings was the sharing of information and the generation of ideas to stimulate the company's new product development strategy. Map 1 (Figure 8.13 details in

Table 8.26) shows the informal NPD Committee network at this early stage. The transactions are information, knowledge and ideas about the NPD Committee and what it's objectives and role are to be.

Network 1 Dimensions	The network
Size	The network at this stage was informal in terms of its objectives but formal from a hierarchical position.
Diversity	The diversity was limited at this stage involving only the MD, marketing and engineering. The reason being that up until 1998 the company had operated around these areas but had limited benefits in relation to the healthcare market.
Openness	Openness was important to get the best from the actors. At this very early stage it was impossible to quantify the openness. Although, Gary Stevens felt that communication was honest.
Centrality	This initial network was centred around the new MD for him to understand the organisation and develop strategic ideas.
Shape	The shape was centred on the Board and Management highlighting the MD's need to learn, understand and begin to gather knowledge to develop ideas.

Table 8.26: WEL - Network Map 1 Dimensions and Detail

The new NPD Committee that overseas the development of projects within WEL was finally formed in October 1998. The initial network of actors increased to include Gary Stevens (Marketing Manager), Richard Wooler (Technical Manager), Graham Massey (Engineering Director), Gerry Thornton (Materials Manager) and Graham Colburn (Sheet Metal Manager). Initially, the NPD Committee met weekly to decide its function. The meetings then reverted to fortnightly. It was concluded that new ideas, projects and developments had to go through the NPD Committee before being given formal recognition. The NPD Committee set up a project checklist for all projects allowing the examination and monitoring of projects on a regular basis. The Board was also updated monthly regarding the projects. Further roles decided upon included: to examine new ideas put forward in-house; and examine external requests, from potential customers, for products that could be developed. After the initial meeting and a great deal of business and market analysis by the NPD Committee it was decided that the overall role should be to:

> *'The key role however has been to re-address the balance of electrical and healthcare through re-organising customer services, sales and distribution of products jointly with the MD'* (Gary Stevens, Dec. 1998).

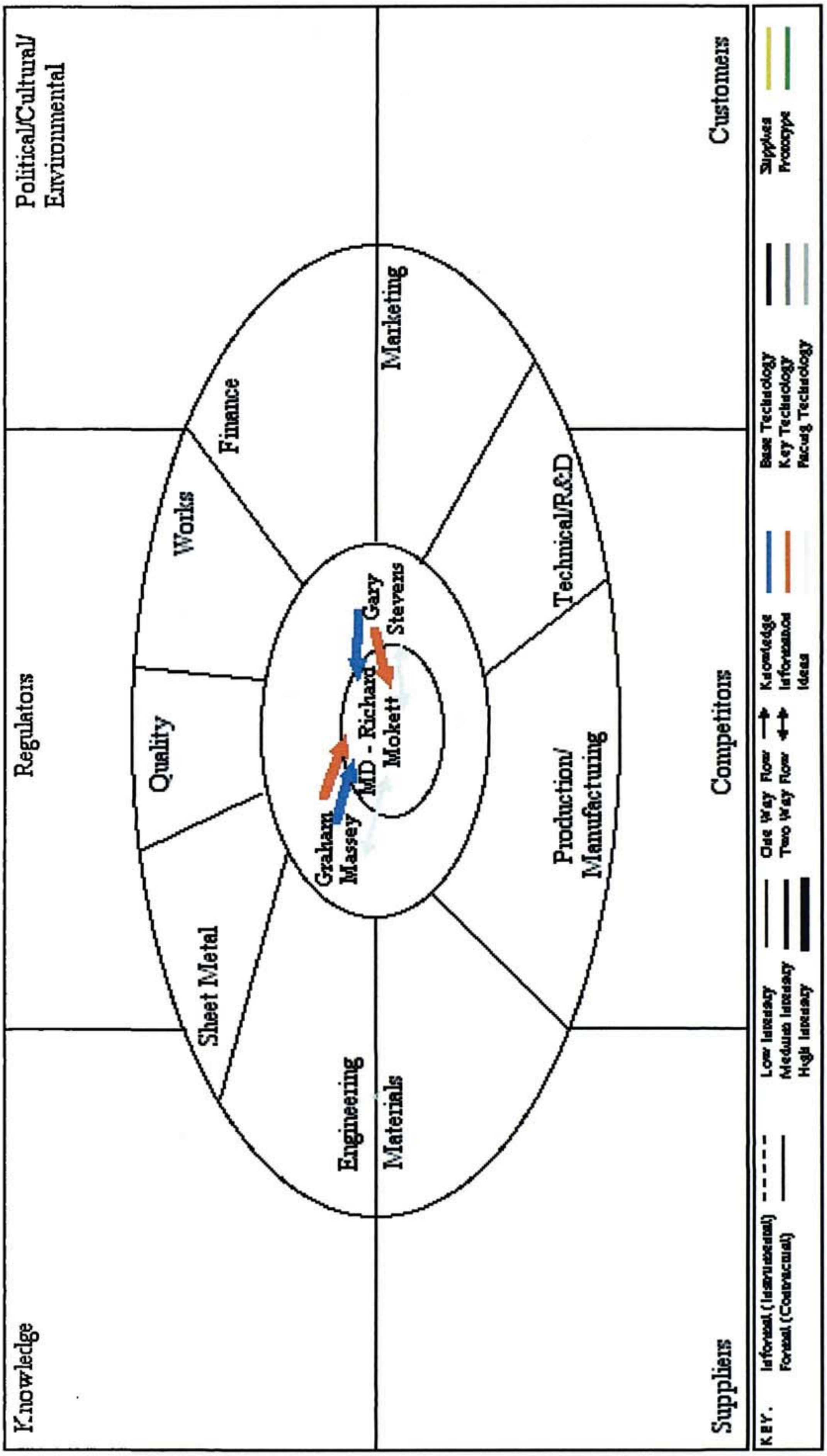


Figure 8.13: WEL Map 1

This began with the redundancy of the Production Director, after 30 years of service due in part to difference in strategy and business thinking including the shifting of business emphasis to marketing and sales. The change also led to a re-organisation of the sales force. Employees where given the option to either accept, obstruct or leave the company with an early retirement package. This allowed the sales force to be restructured from 3 regions to 2 regions plus providing a healthcare specialist in each region to promote the healthcare arm of the business 'which up until now has been lacking in knowledge with the sales force'. Map 2 (Figure 8.14 details in Table 8.27) shows the formal NPD Committee network that was set up to examine and support the developing innovation process within the organisation. The transactions are the sharing of information and knowledge about the organisation and its external environment.

Network 2 Dimensions	The network
Size	The network at this stage was formed around the NPD Committee existing projects were ignored by the researcher. So the NPD Committee network contained 6 formal actors. This NPD Committee had formal links to departments and projects throughout the organisation.
Diversity	The NPD Committee involved managers from across the organisation and therefore the diversity was high in order that information and knowledge could be communicated clearly.
Openness	Openness was important to get the best from a NPD Committee that overseas R&D and projects within the organisation. At this early stage it was almost impossible to quantify the openness. Although, Gary Stevens felt that communication between the individuals had improved.
Centrality	The formal NPD Committee was centred around the Managing Director and key individuals in the strategy making process.
Shape	The shape of the network was circular highlighting the links to the main departments of the organisation. Map 1 shows the circle linking centrally to the MD and then through each individual to the various departments.

Table 8.27: WEL - Network Map 2 Dimensions and Detail

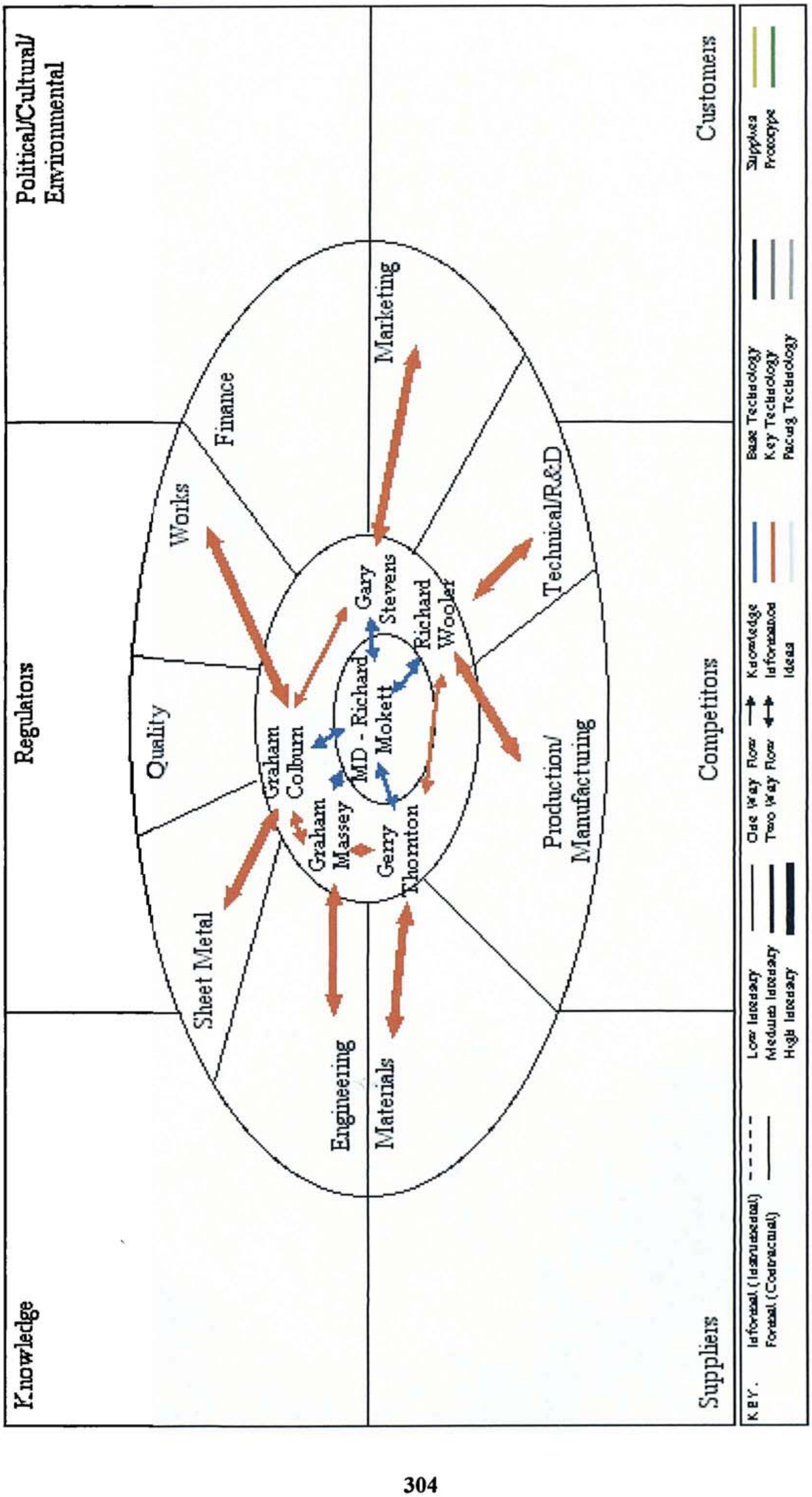


Figure 8.14: WEL Map 2

As a leader in providing healthcare products as well as one of only two major manufacturers of call systems in the UK it was clear to the new NPD Committee that the markets were changing. Cheap Far East products were coming into the market although 'very much at the bottom end' and the change in the health service with the Private Finance Initiative (PFI) which WEL felt had slowed down the building of new hospitals and investment in new products. However, recent government initiatives have meant that in the next three years the market will open up with a number of new hospitals being built and an increase in the number of nursing homes in the UK. This latter change in the market was viewed as a major market opportunity. The new Labour government at the time promised new hospitals by the year 2000 and in 1998 it was apparent that the private money was moving into private nursing homes. These were unlikely to be newly built homes. This provided WEL with a market and new product opportunity based on current products. Nursing homes regulations are different to those in NHS hospitals. Call systems in nursing homes do not need to be stainless steel but can be produced in plastic casing which are cheaper. The main issue however was the fact that the system could be based on transmitter and receiver technology rather than cable as fitting which required a great deal of work and was very costly. However, a wall based systems with no cabling can be moved and re-positioned with little upheaval and minimum costs.

This market opportunity was assisted by the fact that early in 1998 WEL was approached by Philips Electronics Ltd (Holland). Map 3 (Figure 8.15 details in Table 8.28) shows the NPD Committees link with the Dutch company and the network orientating itself towards the healthcare market. Philips Electronics Ltd. had been in partnership with a company named Simplex (US) producing nurse call systems for the Dutch market. They had supplied Simplex with the technology for the system. As part of its strategy to recoup the costs of developing the system with Simplex, Philips Electronics Ltd. was looking to global markets to sell the product. The company approached 5 UK firms that produced or were in related markets. WEL were asked if they were interested in the product and if so then asked to put together a sales projection of the technology. Graham Massey presented the NPD Committee sales plan with support from Gary Stevens. WEL took what they thought was a innovative view of the technology generating ideas for the development of the technology (shown in Map 3 - Figure 8.15) - *'taking a futuristic view of the market and where the market could go and be developed with such a product'* (Gary Stevens, Dec. 1998).

Network 3 Dimensions	The network
Size	The network for the healthcare system projects expanded from the original NPD Committee that was set up. The 6 formal actors were linked with external suppliers including discussions with healthcare organisations and Philips Electronics Ltd. (possible licensing agreement).
Diversity	Diversity increased internally and the project to develop healthcare call systems linked the NPD Committee with particular organisations. External diversity was low to medium and expected to increase with contacts made at healthcare conferences through Gary Stevens.
Openness	Openness in some ways was less of an issue in this case of a project that involves a licensing agreement to access technology. Communication however was vital for WEL and engineers to understand the technology. The licensing agreement was seen to be a learning opportunity for engineers in the company.
Centrality	The final decision to enter into the licensing agreement was made MD with advice from the NPD Committee.
Shape	This network had a strong external orientation since its development. As strategy and direction in relation to market orientation changed the company and the NPD Committee orientated towards the market and developments to innovate.

Table 8.28: WEL - Network Map 3 Dimensions and Detail

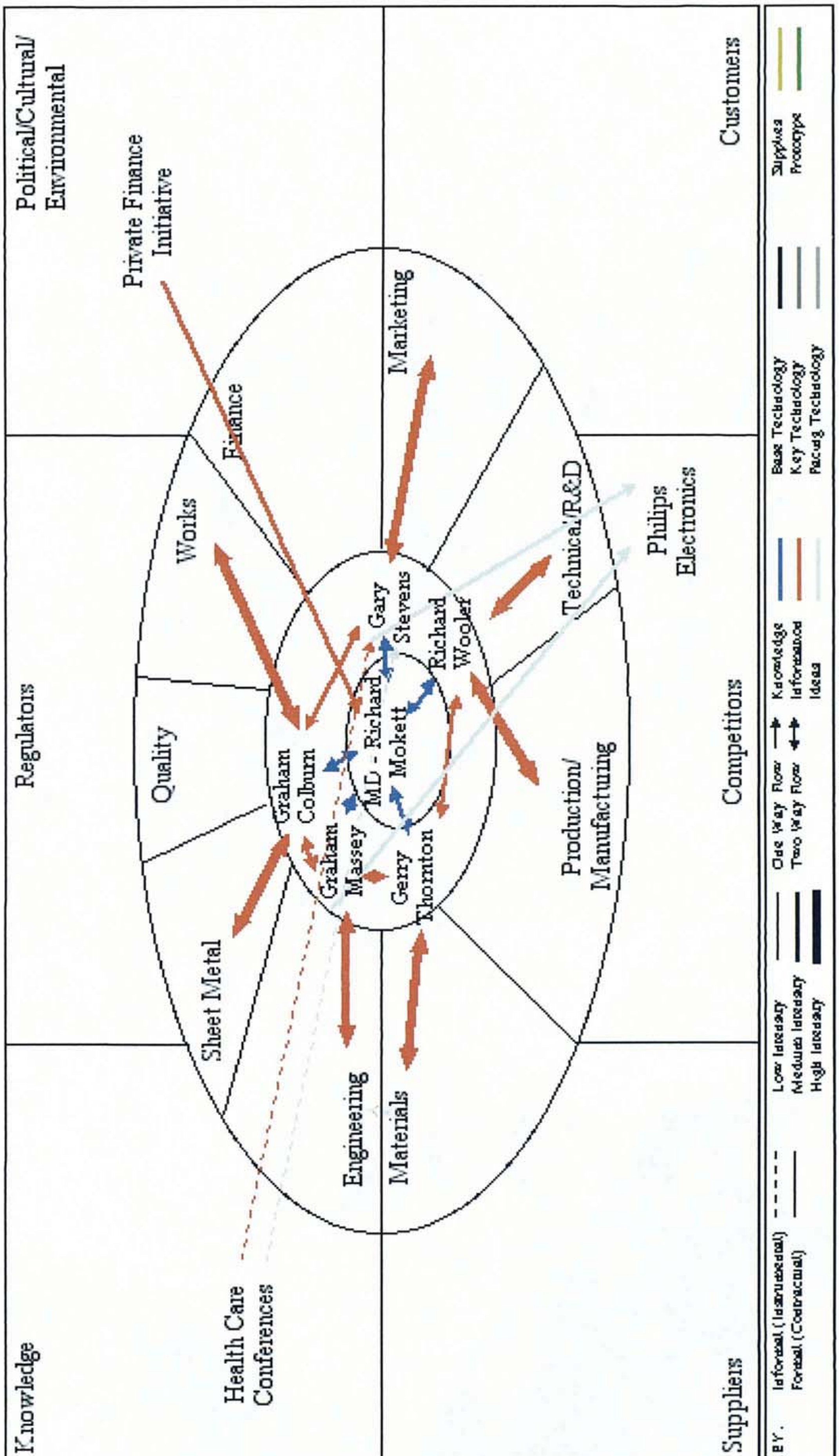


Figure 8.15: WEL Map 3

The view met Philips Electronics Ltd's objectives and the deal was legally ratified. WEL were required to brand the product as their own. The sales and marketing force had to work to sell the product. However, the deal gave WEL a product that met the private nursing home market opportunity with limited development costs. The agreement also stated that Philips Electronics Ltd. would not sell their branded products in the UK and WEL would not sell in Holland. Also if the two approached the same potential customer the one who made first contact was allowed to negotiate whilst the other would not partake in tendering.

Network 4 Dimensions	The network
Size	During this development further links were developed to support the organisations push to develop healthcare systems. Therefore the external size of the network increased further.
Diversity	Diversity increased externally. The attempt of the NPD Committee to access other technologies supported the company's drive to develop the healthcare market and be a technological leader in that market. Informal external discussions with potential technology providers increased.
Openness	With increased external orientation and the attempts to access new technologies the NPD Committee had to be open with engineers on the technologies it was examining and whether the organisation could take advantage of them. Hence the link between NPD Committee members and staff/engineers.
Centrality	The final decision to enter into the licensing agreement was with the MD and support and advice from the NPD Committee. Centrality was high.
Shape	The network had an even greater external orientation since Map 3. The external technological market orientation aimed to support the development of the company's market position.

Table 8.29: WEL - Network Map 4 Dimensions and Detail

A number of other products were examined and some licensed by WEL to supplement its product range but to also provide the company with access to technology. By using market contacts through Gary Stevens and taking part in a number of healthcare conferences the NPD Committee was able to identify developments in the healthcare market and technologies that could be accessed to develop particular new products. Map 4 (Figure 8.16 details in Table 8.29) shows the increased external links with possible technological suppliers of technologies not yet available in the UK at the start of 1999. These links tended to be dealt with by Graham Massey, Gary Stevens and the Technical Manager. Map 4 (Figure 8.16) also highlights the development of the Philips Electronics Ltd. relationship with the license agreement signed. They supplied the technology and also discussions and paper work based on knowledge surrounding the technology. New technologies included tagging systems and pendent worn transmitters. The first was a somewhat controversial technology seen currently in the US to tag criminals on parole and now just coming on line in the prison service here in the UK (December 1998 saw the first tagging of light offenders on parole). *'The big issue is not the technology itself but the social and market perception of tagging.'* (Gary Stevens, Dec. 98). Secure Care Products is a US company that is at the forefront of the development of tagging technologies for private healthcare and hospital use.

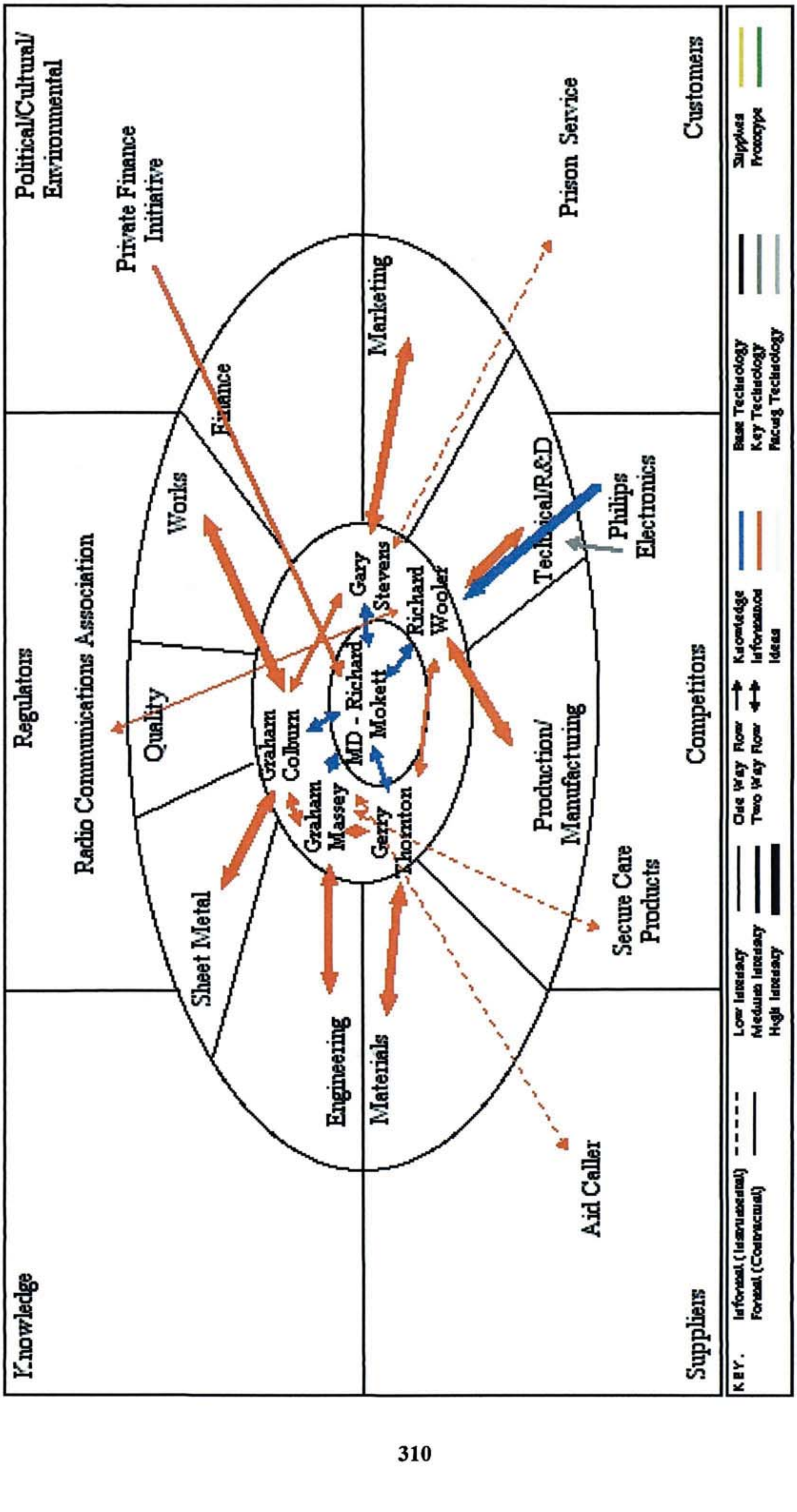


Figure 8.16: WEL Map 4

The two areas WEL was keen to access were the tagging of patients who are medically unfit to leave the home or ward. The second and possibly a stronger market and public application was the tagging of new born babies. At birth the mother and baby are tagged and can both be tracked in the hospital and which are tamper proof. If the baby is removed from the ward by anyone other than the mother then an alarm will sound and if the tag is removed then an alarm will also sound. The tag uses the mother's social security number that is given to the baby's tag. WEL agreed a 6 year exclusive license for this technology in the UK. The technology was beta - tested in the UK at an undisclosed hospital. The Radio Communication Association (RCA) passed all radio frequencies at the start of 1999. The marketing of such products was viewed to have to be carefully dealt with.

Network 5 Dimensions	The network
Size	The network size had not changed at this stage but external actors did. Contracts were signed to supply technologies. Therefore formalising the network in external areas.
Diversity	Formal Diversity increased externally. The NPD Committee identified formal agreements to access technologies from external companies.
Openness	With the continuing development and access of external technology increasing links developed in-house. Production and manufacturing was also looking to play a role in producing new products.
Centrality	All external actors are linked to the central NPD Committee. Centrality is therefore high.
Shape	The network increased its external orientation since Map 3 or 4. The added external companies that would supply new technologies to support the development of the company's market position.

Table 8.30: WEL - Network Map 5 Dimensions and Detail

Care homes are also a key part of the market that WEL sees as an opportunity to expand its product range and develop its product base. The healthcare conferences attended provided the NPD Committee with information on companies operating in this area. Aid Caller, a company owned by Age Concern which does not produce/manufacture products but develops its own patent, designs and licenses these to external manufacturers was identified early 1999 (see Map 4 - Figure 8.16). One particular patented idea/innovation was a neck worn pendent which could be RF connected to a phone. It allowed the wearer to, in an emergency, send a signal to the aid call unit that would ring through to a doctor or emergency unit to respond to the caller. This would require WEL to manufacture the product. An agreement was reached with Age Concern and Aid Caller to license the product exclusively for an undisclosed fee. WEL set the manufacturing process in motion with tooling and machining by January 1999. This product potential gave the company access to designs and knowledge on RF transmitter and receiver technology that complements the knowledge and competencies being accessed from Philips Electronics Ltd. as part of the agreement for training. Map 5 (Figure 8.17 details in Table 8.30) shows the development of the informal discussions with external actors to supply technologies becoming formalised and supplying technology. Formal external orientation increased but was clearly orientated at this stage only in relation to the healthcare market. In-house developments continued with the NPD Committee examining new ideas. Most were additions to product lines or incremental modifications to take into account market trends and in the case of healthcare, nurse practices. Such developments included hospital bed head systems which included lighting modules (developing in-house lighting competencies) - '......*there is cross fertilisation of products within the organisation*' (Gary Stevens, Dec. 98).

The company was still waiting for Home Office specifications for call systems in the UK prison service. This was due December 1998 but had not arrived by March 1999. A final development was activity call system logging. The move to this call system technology was spurred by the trends in the market that was requiring activity logging for litigation purposes. Such information could be crucial in court cases. Ultimately the NPD Committee hoped that the acquisition and licensing of all the technologies discussed would lead to an increase in internal competencies in order that the WEL may develop new products and technologies.

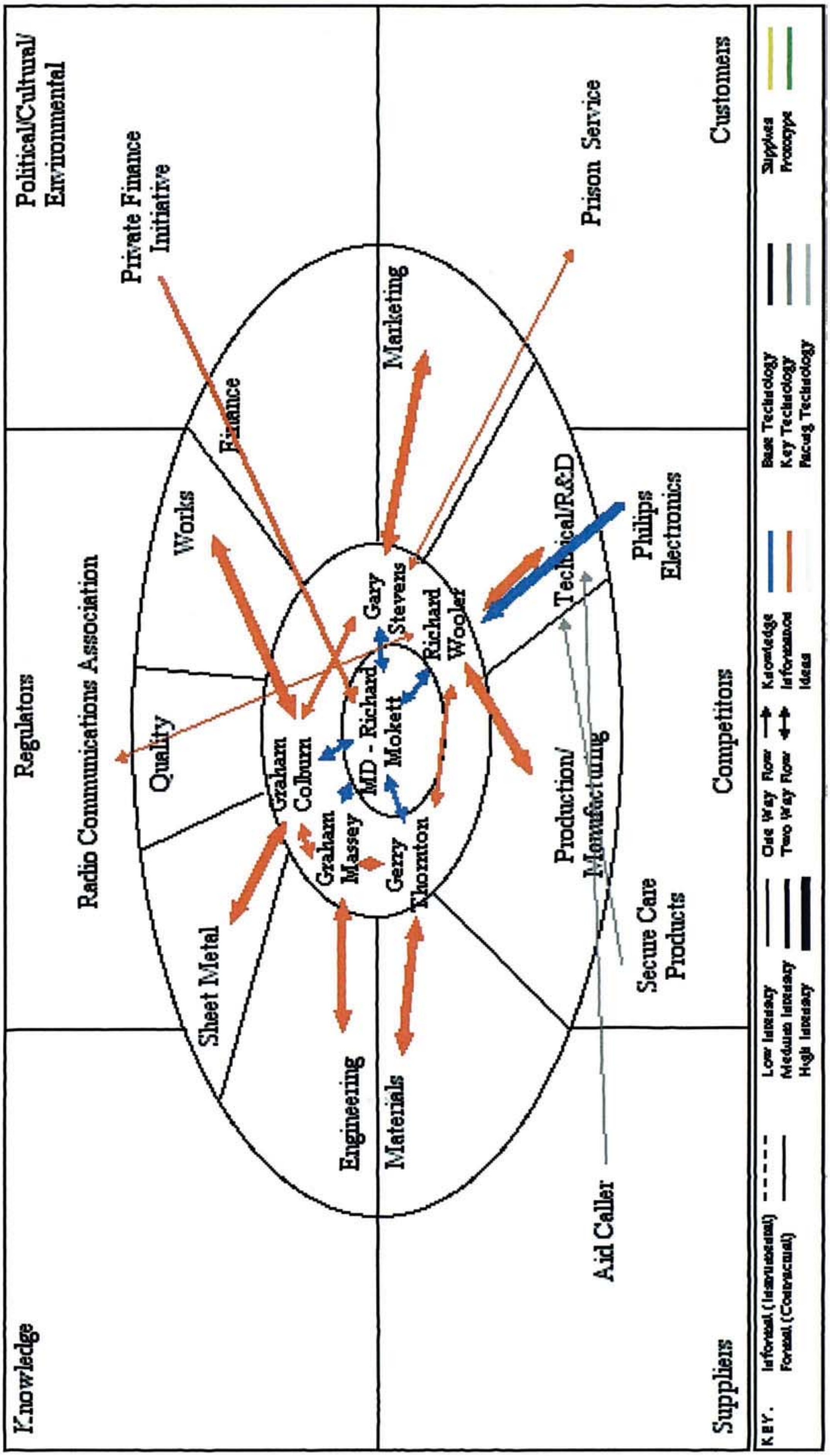
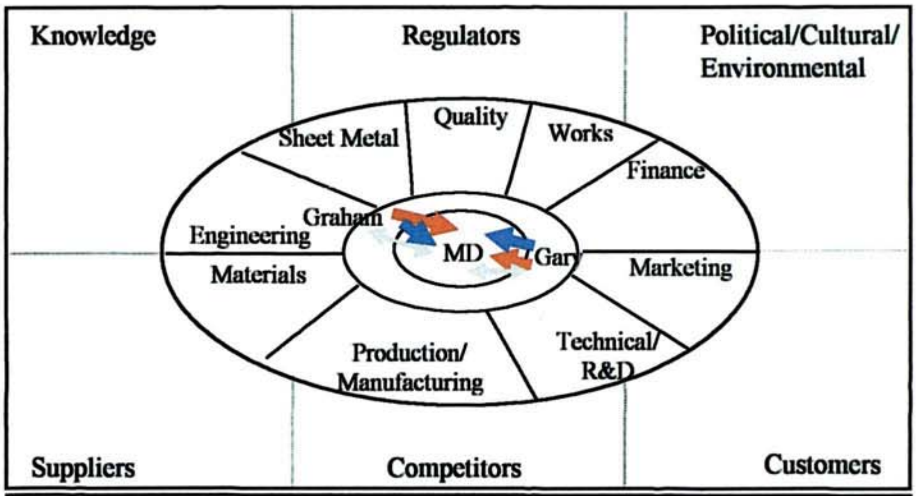


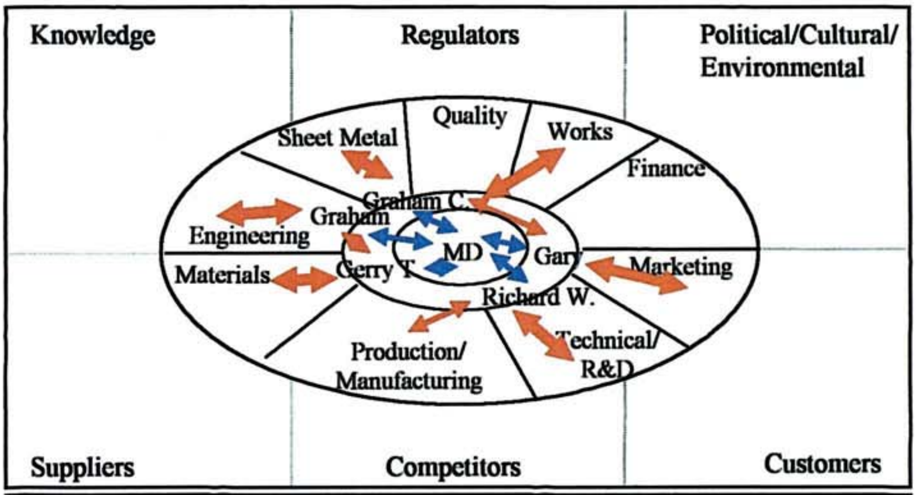
Figure 8.17: WEL Map 5

8.11 WEL: NETWORK SUMMARY & FRAMEWORK ANALYSIS

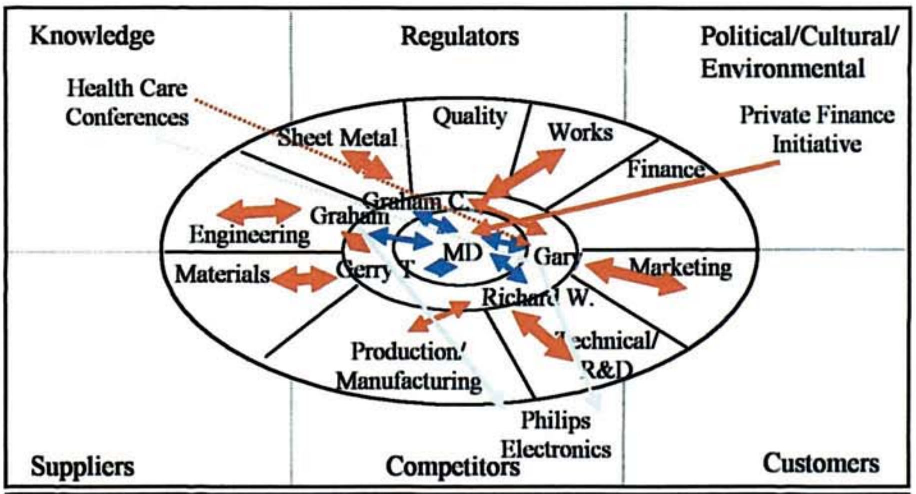
The WEL network is quite different to those analysed in the other cases. The case was based around a network that was viewed by the firm as a new product development team which aimed to examine and generate business, ideas and technologies that can be accessed and brought in-house to aid the competitiveness of the firm and support future new product development. The NPD Committee was clearly an idea of the new MD Richard Mokett at the start of 1998. At this stage (Map 1 - Figure 8.13) the network involved key senior managers and decision-makers from various departments within the organisation. The team's first area of business was to re-address the balance between electrical business and healthcare. In-house technologies were limited and competencies to develop new technologies and products were viewed as week by Richard Mokett and the Engineering Director Graham Massey. Therefore, the decision was made to look externally to suppliers and customers that might provide the firm with the potential to access technologies and knowledge that could develop new business, products and markets. Map 2 (Figure 8.14) highlights this external orientation towards healthcare organisations. Maps 3-5 (Figures 8.15, 8.16 and 8.17) also show the accessing of technologies through links with external actors. Internal diversity of actors is stable across the network maps although external diversity changes over the period of the research. But this is important to develop and access new technologies. The shape of the networks became increasingly dense as the network developed externally but stayed relatively unchanged internally. The shape indicates and supports the fact that the network was internally driven via the core network of the team (Map 2 - Figure 8.14). The network was centrally driven in terms of its objectives with strong links to the strategic decision-makers. The links these individuals had with functions and departments of the organisation meant decisions were made on projects and developments based on all available information and internal knowledge. So far the accessing of technology has been through licensing in the main, with the contracts drawn up providing WEL with a relatively strong UK market position with suppliers not competing at the same level. Figure 8.18 summarises the individual network maps (1-5).



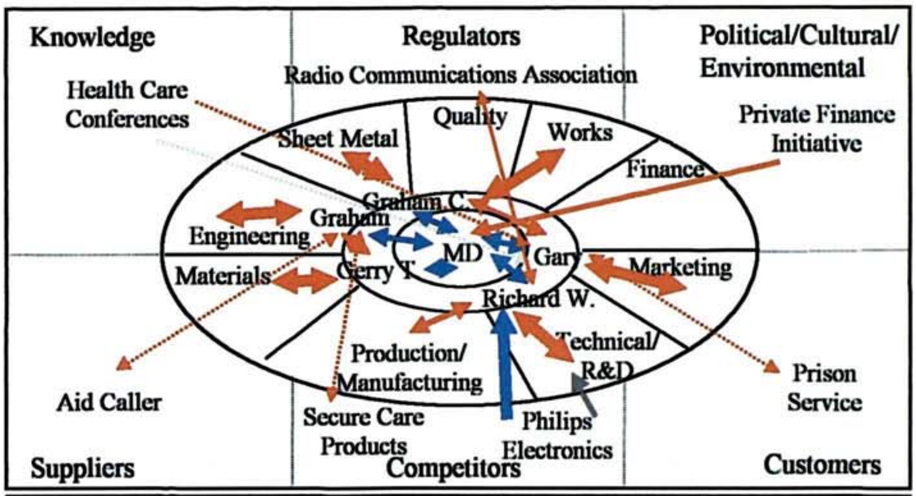
Map 1: Idea Network: Size - 3 actors; Diversity - Low ; Openness - High in relation to Board; Centrality - High; and Shape - Internally driven.



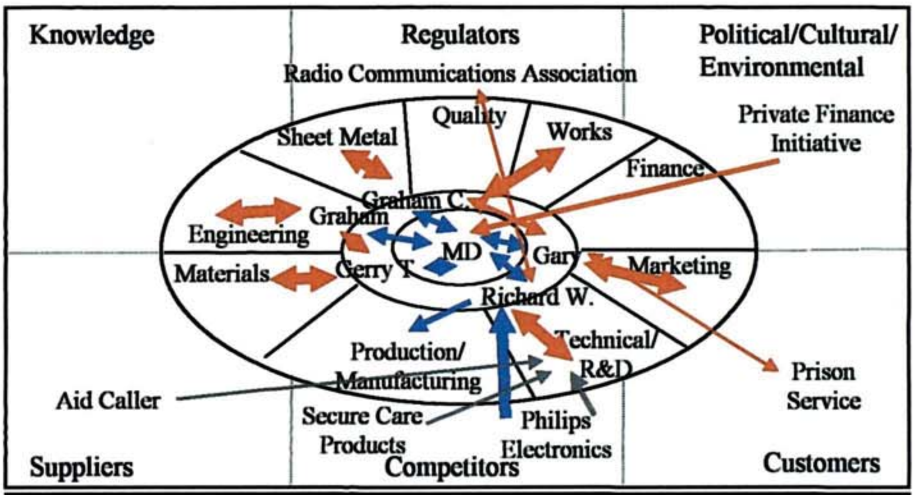
Map 2: Formal Network: Size - 6 actors; Diversity - High ; Openness - High in relation to Board and Organisation; Centrality - High; and Shape - Internally driven crossing all internal boundaries. Each formal actor acting as a boundary spanner.



Map 3: Strategic Network: Size - 6 internal actors plus 3 external; Diversity - High internally ; Openness - High in relation to Board; Centrality - High; and Shape - Internally driven but with an external market orientation.



Map 4: Strategic Network: Size - 6 internal actors plus 7 external; Diversity - High internally and externally ; Openness - High in relation to Board; Centrality - High; and Shape - greater external orientation providing greater opportunities.



Map 5: Supplier/Manufacturing Network: Size - 6 internal actors plus 6 external; Diversity - High; Openness - High; Centrality - High; and Shape - internally orientation with external actors supplying information and key technology.

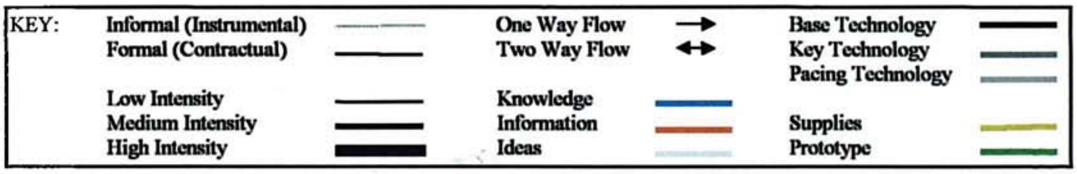


Figure 8.18: Summary of WEL's Strategic Innovation Networks (SINs)

8.11.1 WEL: Accumulated Technological Competencies & Networks

The core competence of WEL is electrical engineering and increasing competencies in electronics. All products utilise the same technologies that are applied to differing products and markets. Because the same broad base of technologies are used throughout the organisation means that the most likely new products/innovations to be developed will be based on electrical technology. Table 8.31 summarises each of the actors in relation to their relationships and transactions that link to accumulating competencies.

Actor	Relationship	Transaction Content	Other
Richard Mokett	**Managing Director** instrumental tie	Strategic Thinking - Business Understanding and Knowledge	
	Intensity - Medium to High with all actors in NPD Committee. Low with department actors.	Value - High to drive Board, NPD Committee and ultimately innovation.	
Gary Stevens	**Marketing Manager**	Information - markets, competitors and sales teams	
	Intensity - High with NPD Committee and marketing and sales department.	Value - High providing information and knowledge and feedback from sales teams.	
Graham Massey	**Engineering Director** -	Decision on engineering projects. Involved in all previous developments.	
	Intensity - High with NPD Committee and engineering department.	Value - High in relation to engineering ability and knowledge of current organisational skills and competencies.	
Richard Wooler	**Technical Manager**	Process and Technical Knowledge	Openness
	Intensity - High with NPD Committee and R&D - production/ manufacturing.	Value - High, as knowledge relates to technical understanding of current organisations and has ideas for future developments.	This is an important element here. The champions need to be open and pass on their knowledge about the software to individuals in the departments.
Gerry Thornton	**Materials Manager**	Strong understanding of manufacturing processes.	
	Intensity - High with NPD Committee and materials department plus low to medium intensity with suppliers.	Value - High especially in relation to links with suppliers.	
Graham Colburn	**Sheet Metal Manager**	Good ties with shopfloor.	
	Intensity - High with NPD Committee and medium intensity with suppliers.	Value - High to medium given direct links to the lower hierarchical levels. Help to understand the impact of projects and any change that might develop.	

Table 8.31: WEL - Accumulated Technological Competencies & Network Variables

The basis of the NPD Committee to examine and develop innovation within the company led at its early stage to projects that utilised external actors to supply technologies in the area of electrical and electronic technology. This provided the company with some competitive advantage and the ability to develop its product range to meet new market opportunities. Technologies relating to the electrical side of the business have generally been base technologies and available to all. However, the NPD Committee accessed electronic and RF electronics that offered the company key technologies. The competencies that have been accessed through licensing and joint ventures provide the firm firstly with supplementary competencies that support existing competencies and new competencies in relation to tagging systems.

8.11.2 WEL: Internal Strategic Cohesion & Networks

The purpose in setting up the NPD Committee was to develop the firms markets and businesses through innovation, new product developments through strengthening the company's internal strategic cohesion. Each individual making up the NPD Committee during the research was either a Board member or key manager within the organisation. Each more importantly was expected to drive projects that the company got involved in. The business areas affected were dependent on the market application. An example being Graham Massey who was the Project Leader for the digital hospital communication system. Each individual on the NPD Committee is the team leader within the business areas of the organisation thus providing formal links with engineers, R&D, marketing, operations ect.

Actor	Relationship	Transaction Content	Others
NPD Committee	Reciprocity - Bilateral between team	Activity and new development support	High Diversity
	Multiplexity - High given broad base of links.	Information/Know How	Shape - Internally Focused
			Centrality is high with a major influence throughout being the Chairman

Table 8.32a: WEL - Internal Strategic Cohesion and Network Variables

Actor	Relationship	Transaction Content	Others
NPD Committee with Board	Reciprocity - Bilateral	Information, Knowledge and influence over decision making	High Diversity internally and increasing externally.
	Multiplexity - High	Knowledge and ideas	Internally Focused
			Centrality High- NPD Committee based around the Board.

Table 8.32b: WEL - Internal Strategic Cohesion and Network Variables

The link between NPD Committee members and actors throughout the organisation aimed to develop ideas and place them on the strategic agenda. During the research it was not clear exactly how this might be done apart from individuals being encouraged to put forward any ideas they may have to the NPD Committee. The main aim was to access internal knowledge and information held by individuals within departments. Therefore, each NPD Committee member was made a formalised boundary spanner with a direct link to the Managing Director (Maps 1, 2 & 3 - Figures 8.13, 8.14 and 8.15). The internal strategic cohesion is supported by the diversity of actors within the network and the shape of the network which spread across the organisations functional boundaries. However, up still 1999 the network had focused externally in an attempt to access technologies and learn from potentially more innovative firms (Maps 3 & 4 - Figures 8.16 and 8.17).

8.11.3 WEL: Organisational Specialisms & Networks

The organisation's specialism is in electrical equipment. However, the market and internal changes see the specialism slowly moving towards digital and electronic equipment. However, such equipment continued to require electrical knowledge and understanding. The NPD Committee network was designed to be embedded in the organisation (Table 8.33) and around the company's specialisms especially with the inclusion of Graham Massey. *'Wandsworth's, openness has improved in the last five years especially with the personnel changes within the organisation'* (Gary Stevens, Nov. 1998).

Actor	Relationship	Transaction Content	Other
NPD Committee link with Company	Formalisation - High	Information - and Training Knowledge	Externally Focused - Shape
	Intensity - High		High Internal Diversity

Table 8.33: WEL - Organisational Specialisms & Network Variables

The relationships although not contractually formalised (in relation to the NPD Committee) continued to be highly formalised in relation to the hierarchy of the organisation and the fact that all individuals are involved on the Board.

8.11.4 WEL: External Orientation & Networks

The external actors that impacted on the organisations products and the NPD Committee were: N.C.Systems which produces the healthcare technical memorandum which provides information on the market, competitors technical requirements and NHS Estates who produce the regulations and operational characteristics for call system products - these were viewed as very restrictive. The HTM by 1999 did not allow two way speech through call systems. However, the NHS guidelines were slowly being overtaken by the Private Finance Initiative guidelines and between 1997-1999 changes had been more forthcoming. It must be said that all UK call system companies were involved in the creation and development of the HTM. - *'This does allow the companies to push for change but it is slow'* (Gary Stevens, Dec. 98). The diversity of external actors increased to strengthen the potential for technological opportunities. Table 8.34 summarises the internal actors' links to external actors. The Radio Communication Association is also a body that became more important to WEL. The association gives permission to firms to transmit RF signals at certain frequencies this is more important now more than ever with the development of wireless technology for call systems. The Secure Care product had US approval but not UK RF transmitting approval. Aid Call was not affected as the organisation already had permission to transmit.

Actor	Relationship	Transaction Content	Other
Graham Massey & Gary Stevens	Philips Electronics Ltd. Multiplexity - High technical staff of Philips Electronics Ltd. Reciprocity - Bilateral	Presentation to provide business outlines. Ultimately the presentation led to a deal to access and license a particular piece of technology.	Diversity - High - ranges from customers to suppliers to regulatory bodies.
NPD Committee	Other healthcare companies Multiplexity increasing externally in terms of healthcare links with various bodies. Reciprocity - Bilateral	Information, influence and knowledge.	
Richard Wooler	Radio Communication Association - Multiplexity low but increasing interaction. Reciprocity - Unilateral	Information and regulatory agreement in favour of WEL.	

Table 8.34: WEL - External Orientation and Network Variables

8.11.5 WEL: Management Skills & Networks

The individuals involved in the NPD Committee are all actors who had been involved in the decision-making process within the organisation (Table 8.35) making key business decisions but more importantly all had been project leaders. They therefore brought strong ties to individuals across departments to the NPD Committee. All had project management experience and knowledge of current projects and ideas of the projects required to move the business forward.

The Managing Director was the most influential individual in relation to getting the NPD Committee (Map 1 - Figure 8.13). The external orientation of individuals within the organisation and actors on the NPD Committee benefited the organisation by providing links to associations and bodies that have provided the firm with links to access technologies and enact its strategic plan. Graham Massey had a key role in the management of external and internal information acting as the boundary spanner between the organisational departments and the NPD Committee as well as linking the company with external actors.

Actor	Relationship	Transaction Content
Richard Mokett	Instrumental & affective ties	Strategic Information & Knowledge
	Multiplexity - High with NPD Committee individuals	To make key business decisions based on Boards information and knowledge.
	Formalisation - High	Value - High
Graham Massey	Instrumental & affective ties	Information - Strategic & Company
	Multiplexity - High with NPD Committee, and engineering and production.	Manage and formalise the project
	Formalisation - High	Value - High with engineering background knows what can be achieved. - skills and equipment.
Gary Stevens	Instrumental & affective ties	Knowledge and Information about markets and sales divisions.
	Multiplexity - High within NPD Committee and marketing and sales	To provide knowledge and information about markets, competitors and sales.
	Formalisation - High within core team	Value - High given his market and sales knowledge including competition.
Richard Wooler	Instrumental & affective ties	Technical knowledge and information about current in-house competencies and skills.
	Multiplexity - High within NPD Committee and technical department.	To provide information of current technical knowledge in-house and areas that might develop.
	Formalisation - High within technical staff and NPD Committee	Value - High given technical knowledge.
Gerry Thornton	Instrumental & affective ties	Information based on current materials and manufacturing abilities.
	Multiplexity - High within NPD Committee and materials department. Also strong ties with suppliers.	
	Formalisation - High	Value - medium to high.
Graham Colburn	Instrumental & affective ties	
	Multiplexity - High within NPD Committee and supplies	
	Formalisation - High	Value - medium to high

Table 8.35: WEL - Management Skills & Network Variables

8.12 WEL SUMMARY

WEL managers have taken a rather different view of the innovation process in that it examines a NPD Committee set up to develop the business and markets through accessing new technologies, developing new products and learning from external sources. In examining the NPD Committee using the SIN framework I identify a project that began to help WEL access new markets. The new product development project begins with the setting up of a NPD Committee. This led to WEL increasing its external orientation and developing relationships with firms, regulatory bodies and healthcare actors in order to develop the business. The first action out of this NPD Committee was the licensing of new technologies from Philips Electronics Ltd. highlighting the thinking of the NPD Committee and the MD Richard Mokett to re-balance the business, raising the profile of healthcare within the organisation through accessing new key technologies. The NPD Committee developed the competencies of the organisation by re-orientating its current projects to incorporate new technologies. Developing the internal competencies of electrical equipment to electronic equipment, RF technologies and digital communications. The developments of the business and how innovative WEL wishes to be in the healthcare market was limited by the likes of the Public Healthcare Initiative. Therefore, the accessing and development of new technology is based on key technologies that exist but are used in other applications. The technology accessed provided benefits to the organisation to develop its public healthcare business but more importantly the increasing private healthcare system in the UK.

8.13 CONCLUSIONS

The supplementary cases presented add further value to the use of the framework and its utilisation in examining and understanding the innovation process from a strategic and network perspective. The maps throughout the three cases show very clear differences in the networks during the projects. The differences relate to corporate strategy, resources and skills available in terms of actors, project requirements and external orientations. In all three cases the Board were instrumental in the projects happening. Table 8.36 summarises the differences between the firms. Of all the cases discussed in this thesis only the OCL's TMS project innovation failed to meet its objectives. This was not due to a poor or non-competitive product as initial interest and early sales was viewed as potential for the product. However, mass market development and sales were two years away given information supplied by US and European mass car manufacturers and tyre manufacturers. Given the interest from Morgan Cars and motor-sport, it begs the question why did the TMS team not examine the after-sales market more closely. Unfortunately unplanned external difficulties made the Board's decision to cancel clearer. DDL and WEL are as yet not in a situation where failure is likely to occur. But the way WEL went about accessing technology basing it on in-house strengths, market regulations and available technologies would suggest the potential for new product development and success is greater. The company is taking incremental steps forward in its technology based around its core competencies rather than making great leaps as in the case of OCL. This is clearly shown in the maps of the three cases with OCL concentrating its external orientation on knowledge and potential customers without any formalised agreements which puts the access of technology and the new product development at risk if the talk is purely rhetoric. With WEL the relationships with external sources were formalised and involved licensing and joint ventures to access technology and develop products for markets that the company specifically operates in and has prior knowledge of before development commenced. DDL is solely internally focused which is historically how the firm has been run with strategy based around the core competence of paper honeycomb production. The process development may lead to innovation in manufacturing and business processes - external orientation is very limited. The cases vary in their Board involvement in the project and general strategic management of the technologies. WEL and DDL appear stronger in relation to internal strategic cohesion between Board and NPD Committee. Where as OCL at the stage between 1997-1999 had limited links between the Board and the TMS team and the team played no part in the strategic decision-making process. Although prior to cancellation the Board would have considered the strategic merit of continuing with the TMS project. In all cases the role of boundary spanner was vital to direct the development of the projects. They acted as a bridge to information and knowledge and to a lesser extent ideas either externally orientated or especially in the case of DDL internally orientated. The role is an important element of the management skills of the strategic management of technology in managing internal and external orientations.

	OCL	DDL	WEL
Strategy	Board re-orientated the corporate strategy to allow for new technologies and products to be considered and developed.	No change in corporate strategy but the IT project aims to develop the information generated in the organisation to develop new business strategies based on current technologies.	New product development strategy to access technologies to develop new products to meet developing business areas. New product development through new NPD Committee.
Resources	Limited at the early stages. Increased with the development and then removal of the electronics department. Strong project management skills in-house.	Internal resources limited but used individuals as information providers and with Mike Burnell's software skills and the Board dictating the requirements.	The technologies being examined and considered linked closely to internal developments in transmitting and communication technology.
External Orientation	Limited customer orientation but a number of knowledge actors were important. Only at the later stages of the project did customers, suppliers, competitors become of value to the firm.	Limited - only suppliers of software packages. Purchase of off-the-shelf software.	External orientation is very important to access new technologies and develop a customer base and market for developing products. Licensing seen as an important factor in technology access.
Competencies / Knowledge	Limited at start - however during 1997-1999 period skill level high and knowledge.	Knowledge not a major requirement.	In-house competencies fit new technologies although some learning and knowledge access required to utilise product in the most valuable way.
Competition	Relatively limited with very few firms producing such a device for the private automobile market.	Not seen as important for how the project was run but the information to come out of the packages had to be of value to management and Board to make decisions on business strategies.	In its markets WEL is a leading organisation. However, the nature of some of its markets (healthcare) is changing and to stay in front the company must develop new products around its existing competencies whilst also adding to those competencies.

Table 8.36: Summary of Cases and Differences in Networks

Of the three cases the strategic orientation appears greatest in WEL and OCL. WEL's corporate and implicit technology strategy focused on developing new technologies in new products based on current and related competencies. OCL concentrated on current technology adding value through incremental changes to current products whilst continuing to improve processes to aid cost cutting and competitiveness. DDL is less clear in this respect. It concentrated on its main competencies and technologies with no sign of development. Its management of technology focused on the management of information to support the business and the product.

Chapter 9:
DYNAMIC TECHNOLOGY STRATEGY

CHAPTER 9

DYNAMIC TECHNOLOGY STRATEGY

9.0 INTRODUCTION

In this chapter I utilise the research data to examine the propositions discussed in Chapter 5. In doing so the total set of SIN frameworks mapped for each case study are used to develop a dynamic network understanding of the innovation process. The key propositions upon which the discussion is based are:

- the types of networks employed to achieve particular innovations follow corporate/technology strategy
- assuming the innovation process is not static then there will be identifiable network stages each adopting particular network types

The propositions (Chapter 5) provide the basis on which this discussion develops. At the beginning of each section key propositions for each will be re-stated in order to meet the following objectives:

- to show that network structure follows corporate/technology strategy
- to show that the network mapping contributes to the understanding of strategic management theory
- to show that process innovation and product innovation require very different network developments
- to develop a network understanding of the innovation process that will provide strategic decision makers with options for particular corporate/technology strategy
- to offer a dynamic understanding of the network process underpinning innovation

Ultimately the aim is develop a dynamic understanding of the innovation process from a strategic network perspective. Firstly, I believe that the innovation process within each case study is informed and shaped by the strategy employed. The SIN of each case study identifies a number of changes to networks over time and strategy decisions at the corporate level affect the network(s) and the ways in which they function as well as the organisational goals. Therefore the discussion will show that particular network types follow corporate/technology strategy. Secondly, I discuss the two main cases in terms of product and process innovation theory. Utilising the SIN frameworks to examine two different innovation types that may require different network types. Do these networks match the theoretical perspectives (Porter, 1985; Anderson & Tushman, 1997; Henderson & Clark, 1990; Goodman and Lawless, 1994) outlined in Chapter 2? Thirdly, firms employ different forms of networks to deliver the innovations. From the analysis I identify definite network stages during the innovation process. Hence I suggest where innovation success can be won or lost through the network process. Therefore, I will identify the factors that shape the network stages. Finally, each networking stage is examined in relation to the individual variables (such as multiplexity and openness) in order to provide a clear indication of the value of each variable in relation to the network stage. This network development in relation to technology strategy and SMOT provides the aforementioned with a dynamic perspective.

9.1 TECHNOLOGY STRATEGY IN MID-CORPORATE FIRMS

The development of a technology strategy will specify, within a given horizon, targets for the research and development as well as the acquisition and exploitation of new technologies. However, as discussed in Chapter 2, technology strategy does not necessarily have to be formally developed. The key to its potential success in stimulating and developing competitive advantage is its integration with corporate strategy (Berry and Taggart, 1998). This view would appear to be evident from the cases as none of the organisations had a specific technology strategy. However, OCL and SUA are incorporating the development of technology within their corporate strategies. In the case of OCL the network analysis shows the importance of external orientation towards knowledge. In doing so OCL has identified and acquired technological opportunities whilst increasing its external multiplexity of relationships potentially adding to the number of technological opportunities. SUA on the other hand utilised internal R&D and competencies to develop potentially innovative products based on improved market analysis through external orientation.

Itami and Numagami (1992) define three types of strategy which consider technology (discussed in Chapter 2). In the following sections I examine each case to identify the type of corporate/technology strategy.

Type 1: Current strategy capitalises on current technology

Type 2: Current strategy cultivates future technology

Type 3: Current technology drives cognition of future strategy

SUA has developed its strategy because of an over-reliance on customers like Rover Cars. SUA through its strategy of integrating current technologies and competencies (Map 2 - Figure 7.2) has integrated products to develop product systems. The Air Assist Fuel Injection (AAFI) is an example of a future technology providing competitive advantage over current fuel injection technologies. It is this type of technological development that the organisation aims to repeat. This approach to the market has seen new ideas developed in-house that are expected to transfer into new technology-based products and systems that will strengthen future market position and competitiveness. Some of these technologies were patented at the start of 1999. Therefore the company is moving from a Type 1 to a Type 2 strategy. The aim is to no longer rely solely on current technologies but to cultivate future technologies. The likely success of this move is unclear at this stage but the development of greater external orientation in relation to the market and technology and developing internal competencies around system technologies especially in relation to emissions would appear to be a good move for the future. The value of this strategy approach may prove great given the changes at Rover during March 2000.

Historically, DFM based its strategy on manufacturing processes and was orientated towards the customer and profit maximisation taking a classical approach to strategic management. The late 1990s saw a change in strategy to capitalise on old and current technology. The project was a dramatic move for DFM in terms of implementing new IT manufacturing technologies that go beyond old MRP systems and utilise software solutions to link departments as well as customers and suppliers. This will increase the efficiency and effectiveness of manufacturing processes across the organisation. The development of processes capitalises on current technologies and base technologies (Little, 1981) in conjunction with knowledge (Map 3 - Figure 7.8) rather than capitalising on future technologies. However, it is the approach to current technology and the work with David Riley that made the process changes of value to the firm. The case shows the development of competitive processes (e.g. use of email to update stocks and orders in real-time with suppliers). Software development was used in a way that means the organisation as a whole and the processes employed could capitalise on current technology. This vision was limited within the firm although the technology has some advantage over competition in relation to stock control and supplier relationships. Therefore, DFM's strategy fits a Type 1 description.

OCL developed a strategy that formed the basis of the business in which the organisation operates. In the late 1980s OCL began to move from a Type 1 strategy to a Type 2 strategy. The original invention of the TMS was based on OCL's own bi-metal technology which meant that if the TMS had functioned adequately the company could have utilised current technology to provide both a competitive advantage as well as a cost advantage over the competition. However, the move to electronics saw OCL shift to a Type 2 strategy. Changes in corporate strategy from current technological competence to examining the external environment and markets for key technologies (Little, 1981) which could have a high competitive impact. OCL pursued a systemic approach to strategic management and technology (electronics) that had potential to impact on its existing and new markets at the start of the 1990s. OCL appeared to be highly successful with its technological competencies and that the accumulation of electronics technology during the early 1990s provided the firm with the potential for competitive advantage. The strategy was to develop technologies that would drive future technological development and position the organisation's strategy in line with a Type 3 strategy. However, slow development, limited returns, ever-increasing problems plus the lack of market orientation during the early development years meant that this drive to a Type 3 strategy failed. During the TMS project (see Map 7 - Figure 8.3) the strategy clearly reverted to an approach concerned with existing technology and competencies (processual approach). The TMS was removed from the internal strategic cohesion of the organisation and the link to organisational specialisms was reduced and the strategy reverted back to concentrating on current technologies (Type 1).

DDL has been a customer-driven firm for some time. Its businesses have been built on a single technology utilised in a number of business areas. This has been relatively successful but recently markets have matured with new technologies coming into the market place. Therefore reliance on existing customers has shifted to new market areas outside the UK. However, the same technologies are being utilised and the strategy capitalises on current technologies - Type 1. The development of the IT project does little at first glance to develop strategy in order to cultivate or drive future technology. However, the project has developed in stages (evolutionary approach) testing software options to centralise current internal information including marketing, sales, inventory and production (see Map 2 - Figure 8.8). The aim was to provide a clear picture of the firm at any given time and areas in which the firm can improve and develop to be more competitive and market orientated in terms of its current technology. The internal focus of the network shows this development of information gathering inside the organisation through what are readily available base technologies (see Map 3 - Figure 8.9).

At the beginning of the research WEL was undergoing many structural and organisational changes the most significant being the appointment of Richard Mokett as Managing Director. The company and its corporate/technology strategy has been market/customer driven following a imitative innovation strategy (Freeman, 1991) since 1987. Until early 1998 a formal mission statement did not exist and any strategic plan for the future direction of the company was not communicated to the management or workforce. This style of management gave the impression of a company being run as a '*rudderless ship*' (Gary Stevens, 1998). The strategy capitalised on current base technology, much of which was copied. The company however has combined technologies in products that can become market leaders. During the company's most recent history new competitive products have been developed to make the company the leader in Health Care products. Prior to the changes in WEL the strategy was Type 1. However, with the advent of the changes in WEL, Richard Mokett wanted to develop the company's innovative capacity as well as new products and markets by capitalising on current technology but more importantly examining new ideas, the organisation's environment and where possible technologies in-house and externally (systemic approach). The strategy is expected to cultivate new and future technologies and eventually products that will improve competitive advantage. A key element to this new strategy, to integrate technology into the corporate thinking and strategy, was the creation of the new product development committee. There has been a definite move in the organisation at the corporate and decision making level to move towards a Type 2 strategy. With the committee formed and the individuals involved the belief is that a Type 3 strategy in time can be achieved.

9.2 THE RELATIONSHIP BETWEEN STRATEGY AND NETWORK STRUCTURE

Berry and Taggart's (1998: 887) assertion that the literature *'often neglects the context within which strategies are generated, chosen and implemented'*. The cases without network mapping and analysis, are limited in what they can tell us about the chosen strategies and the way in which these impact on the organisation and networks. The use of the SIN framework takes the formal strategic management procedures and organises them in such a way as to allow strategy to be examined within the network context. In Chapter 5 I identified two propositions:

- the types of networks employed to achieve innovations follow the technology strategy.
- the type of strategy (Itami and Numagami, 1992) will require particular networks to achieve the objectives.

The maps suggest that the type of strategy does influence the networks. There are similarities between the cases where the same strategy has been undertaken and differences between those that have not. This fits the theory developed by Doz & Hamel (1997: 578) that strategy is not only aided by networks but also impacts on network choice as well as Chandler's (1962: 13) assertion that *'structure follows strategy'*. I believe each strategy benefits from particular network types but can also direct the choice of network(s). I therefore examine each strategy type identified in the cases in relation to the networks used and in doing so relate network types to the strategies. Table 9.1 summarises the networks that relate most strongly to the particular corporate/technology strategy types discussed.

Strategy Type	Strategy/Technology	Networks
Type 1	strategy capitalises on current technology	Internal Knowledge Networks Supplier Networks Information Networks R&D Networks Formal Networks
Type 2	strategy cultivates future technology	Strategic Networks Knowledge Networks Strategic Alliances Informal Networks Innovation Networks
Type 3	technology drives cognition of future strategy	Type 2 networks plus Internal Strategic Networks External Knowledge Networks Regulatory Networks

Table 9.1: Corporate/Technology Strategy Relation To Network Types

Type 1: Attempting to capitalise on current technology requires internal knowledge networks and information networks through committees and R&D networks. The formal structure of the organisation and departmental and inter-departmental networks will aid in generating ideas and opportunities based on current technology. Supplier networks will also be important in providing materials and base technologies that assist in capitalising on current technologies (Tidd et al., 1997 and Von Hippel, 1988).

Type 2: Where a firm wishes to cultivate future technology there is a more strategic approach to networking. A firm needs to develop and differentiate (through enhanced quality and features (Porter, 1985)) areas of competency and knowledge. This can be achieved through internal/external knowledge networks, strategic alliances and innovation networks. These network types cultivate technology in terms of products and processes but also in terms of organisational specialism (Dodgson & Rothwell, 1991). Informal networks at this strategy level can prove valuable as we have seen in the case studies, as they provide connections with individuals and groups not normally available through the formal network process and which can provide opportunities to assist the cultivation of technology. However, these are only valuable if they are identified as such. This requires understanding, learning and communication. Itami and Numagami (1992) highlight the importance of learning within this strategy that supports the development of communication between departments as well as decision-makers.

Type 3: This strategy is inherently influenced by the firm's current commitment to technological development (Itami and Numagami, 1992). To achieve a Type 3 strategy the networks in Type 2 will play an important role. This strategy is strengthened by the ability to support the Type 2 strategy utilising networks that provide information and knowledge of the environment above and beyond the current technology and current developments. Therefore, external networks that form relationships in relation to the market, customers and regulatory bodies in order to monitor changes and developments must support the Type 3 strategy. The aim being that corporate/technology strategy can develop with the market, regulations and customers. These networks are long-term relationships with individuals sitting on groups that are key to strategy and technology development. Senior decision-makers are the boundary spanners as well as key internal actors in relation to technological development as well as achieving current strategy and making decisions on future strategy.

Managers to aid decision making and strategic change may use the mapping of the networks that form the basis of the technological development. Table 9.2 summarises the companies and the networks that were utilised to assist in achieving the strategies.

Company/Strategy	Networks Utilised
SUA - Type 1/2	Internal Knowledge/Innovation Network
DFM - Type 1	Development of internal knowledge networks - Internal Strategic Networks and Supplier Networks.
OCL - Type 2	External Knowledge Network
DDL - Type 1	Internal Strategic Networks - develops into supplier networks.
WEL - Type 2/3	Internal Strategic Committee and External Orientation through market, competitors and customer networks

Table 9.2: Company Strategy and Networks Utilised

The networks vary depending on the organisation's technological evolution and resources available. Resources play a key role in the types of strategies adopted (Bahrami and Evans, 1997) and therefore I argue the types of networks utilised. There is a definite similarity between DFM and DDL as both have adopted a Type 1 strategy and orientated their networks to develop internal processes and technologies. The objective being to assist in information gathering and sharing to assist senior management decision making as well as efficient and effective manufacturing. Both organisations operate very traditional manufacturing processes and management processes and decision-making fits this approach. Therefore a Type 1 strategy is not inconsistent although a long-term approach could provide important external orientations and heightened internal cohesion to generate new ideas and opportunities. It is not inconceivable that both firms could begin to re-examine technologies and external technologies to develop competitive advantage.

SUA's customer focus has helped keep the firm aware of new technologies such as plastic mouldings and resins. However, the firm has tended to develop new products based on internal competencies/knowledge and skills in relation to specific technologies. Even the development of new inventions and systems that could further alter the market place and make SUA a leading and competitive force across the industry utilises internal knowledge networks developing opportunities through internal competencies. For SUA to move beyond reliance on one customer needs the strategy to move specifically to Type 2.

OCL took a network approach that attempted to access external knowledge and skills. In this case internal decision-makers were a key element in this process especially the Technical Director. In adopting a new technology driven approach and focus the firm must continue to monitor market information in relation to such new technologies. This was not done in the early period of this strategy by OCL. The product and its technology pre-empted the market. When taking a technology driven approach to the network the advice would be to be aware of the market and canvas the possible customers and market players to access what the market can except in terms of a new innovative product.

WEL on the other hand has been customer-driven and its networks orientated towards the customer segment of the SIN framework. However, managers realised that to develop new technologies and products and therefore its markets it must increase its externally orientation. Therefore, the company set up a very different network based on a committee structure that linked to all departments as well as the Board. The NPD Committee also orientated itself to access technologies that may provide product development opportunities. The aim being that strategy and internal and external technology can cultivate and capitalise on one another.

To summarise, this section has identified the strategies employed by the case companies in relation to technology and innovation. In doing so I identify the networks that underpin the technological developments. Type 1 strategy tends to be internally organised and this is supported by the orientation of the networks. Type 2 and 3 however organise to increasing degrees externally with the orientation of networks supporting this. Therefore different network types are required to achieve particular corporate/technology strategies suggesting that network structure follows corporate/technology strategy. The following section examines this view in relation to two specific innovation types. I examine whether networks types vary on the basis of product and process developments. Hence, does the network orientation follow innovation type?

9.3 COMPARING PRODUCT AND PROCESS INNOVATIONS

The analysis in the previous section highlights the relationship between different network types (structures) and strategy types. I believe that the type of innovation also highlights the differences in network orientation. In Chapter 2 I discussed differences in product and process innovation (Porter's, 1985 theories; Anderson & Tushman, 1997; Henderson & Clark, 1990; Goodman and Lawless, 1994). These four theoretical standpoints do complement each other. Combining key theories relating to product and process innovations as discussed in Chapter 2 leads to the following propositions:

- Product innovations normally affect more links in the internal value chain (Porter, 1985) than do process innovations.
- Product innovations are more likely to have greater external relationships with the value chain.
- Process innovations usually improve product quality and reduce costs without necessarily disrupting upstream (e.g. suppliers) and downstream (e.g. customer) linkages (Anderson & Tushman, 1997).
- product and process innovations may fall into two categories - (Goodman and Lawless, 1994) individual innovation (does not impact on other products and processes) and synergistic innovation (require interactive adjustments between or among several parts of the innovation and its surrounding processes).

The mapping of the SUA Harrier project shows that the innovation process included the input of a number of actors throughout the organisation's value chain. The maps highlight inputs from the value chain and also that product innovation involves a number of external inputs from customers and suppliers. Customers predominate at the start of the network and developments and suppliers strongly attached near the final stages of the development when tooling and manufacturing are required. What we are therefore seeing is a more individualistic innovation. Elements of the project do not affect other company developments directly however it has impacted on a number of organisational processes. The development of new storage and inventoring processes for the Harrier project impact on general distribution and storage processes.

DFM's innovation involves internal process development. This is illustrated by the incorporation of IT and software development as well as internal organisational changes. The process development is very much an organisation wide innovation. Internal strategic cohesion and internal linkages are high between all departments' as well as strategic decision-makers having an input to the project. Hence, the process innovation falls into the synergistic innovation category. The value chain in this instance is a key part of the process changes in the organisation. The process innovation also has minimal external linkages except those with the suppliers of IT hardware and software development tools. A very similar situation is seen in DDL.

Both product innovation networks show that internal actor relationships are important but they are limited to key, skilled individuals. The impact is not on the whole organisation and there is a strong external orientation to innovation in terms of market, suppliers and knowledge. The DFM process innovation network is internally focused impacting on all areas of the organisation and supporting the need for employees at all levels to play a role in the change. The only external link is with the chosen vendor. Competitors are not a particular concern of the network actors, however the outcomes will be visible to customers and suppliers (e.g. use of email for stock control and re-stocking). Both show that actor skill, knowledge and competencies are important to the project. Developing the network further to examine the current network in the process innovation could be used to show how the networks orientation changes when key personnel change and that Graham Kennet for instance became the key link to the module champions.

In summary the SUA project is orientated externally with the customer having a major impact on the development of the product. The DFM project has a limited external orientation with the majority of developments relying on internal processes and actors. In terms of the two cases the network orientation does follow innovation type:

- Product innovations are externally orientated in terms of customers, suppliers and knowledge.
- Process innovations are more internally focused than product innovations
- Process innovations are less likely to be individual innovations (Goodman and Lawless, 1994)
- IT based process innovations are viewed as more radical in the sense of the procedural and process changes required by every individual in the organisation.
- The more radical the innovation the more likely it is to be an individual innovation (Goodman and Lawless, 1994).

OCL shows a rather different perspective to product and process innovations. The TMS project started as a knowledge-based innovation (Map 1/2 - Figure 8.1) leading to a product and technological development. The early TMS networks linked with other areas of the organisation and with specific product areas. This link was most evident when OCL restructured from a functional to a product basis. At this point the strategy was to develop new products based on new electronics technology for existing markets. The move to a product based structure tended in the case of the TMS actors to cut the formal ties they had with particular areas of the organisation although some informal links still existed. However, the electronics and new technological development strategies did not achieve their goals. The company decided to re-address the strategy and placed greater emphasis on current product developments. Electronics was disbanded however certain breakthroughs by two electronics specialists in the company and pressure from a particular manager meant the project continued as a separate department. The actors shifted from part-time to being full-time and therefore loosing the formal ties they had with product and functional areas. This leads to the TMS project moving from a very synergistic to an individual innovation. Therefore a further conclusion is that:

- Product innovations are synergistic but the degree of internalisation varies with organisation structure and changes in corporate/technology strategy.

The discussion supports the suggestion that the network types follow innovation types. It should be noted that the choice of innovation types within all the cases is based on a number of strategic decisions and therefore ultimately on corporate/technology strategy.

9.4 NETWORK EVOLUTION

The innovations examined derive from new or current strategies being undertaken by the cases. Whether the innovation starts with an external or internal idea the networks appear to show similarities in their development although orientation does vary based on strategy. The longitudinal view taken of particular innovation networks provides a dynamic examination of the innovation process beyond its adoption (Afuah, 1998). The SIN maps developed within the cases highlight significant phases within the development of the innovation. Table 9.3 summarises the network stages I identified within each case (Chapters 7 and 8).

	SUA	DFM	OCL	DDL	WEL
Networks Stage 1	Customer Enquiry	Internal Enquiry	Skunkworks	Feasibility	Feasibility
Networks Stage 2	Design & Development	Vendor Rating	TMS Formalisation	Trial and Test Suppliers	Formalised Committee
Networks Stage 3	Prototyping & Testing	Q&A Business Process	Manufacturing	Access Software	Develop Strategy
Networks Stage 4	Manufacturing and Distribution	Training & Learning	Supply/ Cancellation	Access Software	External Enquiries
Networks Stage 5	-	Going Live	-	Access Software	Access Technology

Table 9.3: Summary of Case Network Stages

The identification of these stages supports the propositions discussed in Chapter 5. These were:

- the same network will not be employed throughout the whole innovation process.
- each network stage will utilise particular network types.

During each network stage there are different options in relation to corporate/technology strategy based on objectives, decision-makers' influence, and the resources available to the organisation. The importance of these options is the change in dyadic links and therefore changes in transaction content and ultimately how transactions occur between network actors. Exploring the cases and the evolution of each project from the initial idea provides a dynamic view of the innovation process and this is mapped in the following five stages. Each stage is examined in terms of the different network types being utilised to achieve particular goals, requirements and strategies. The discussion shows that the networks evolve over time and that each stage provides network choices depending on the strategy approach. From the analysis of the dyadic links in the case chapters I conclude that actors, relationships and transactions change over time. Hence supporting the second proposition above. I suggest that the five network stages of the innovation process are: feasibility; formalisation; internalisation; functional; and operational (Table 9.4). These are not static stages and each can take on varying network forms dependent in part on strategy. The five stages are discussed below.

Stage	Stage Description
Network Stage 1	Feasibility
Network Stage 2	Formalisation
Network Stage 3	Internalisation
Network Stage 4	Functional
Network Stage 5	Operational

Table 9.4: The Five Network Stages

9.4.1 Network Stage 1 - Feasibility

At this network stage new projects begin with the Board and a key manager (such as a business manager) within the organisation examining the feasibility of the technology/potential product. Senior management influences the development choices of the project through the formal strategy. Where the technology is new and limited internal competencies exist senior individuals/actors involved gather information to build a picture of whether the project can be managed internally or requires external assistance. This process is usually informal but can be formal as in the case of SUA. Where competencies do exist companies in this study still examined their accumulated competencies (see SUA and OCL). The main difference between the case study organisations is that they either have a formal process that aid the decision-making process or undertake a more informal process. WEL is an example of a organisation that has seen the benefit of examining internal/external ideas and technologies at the senior management level. This examination focused on organisational competencies and strategy leading to the setting up of a development committee. During this stage a number of network approaches are feasible. Where new technology is being considered, accessed or acquired a firm is most likely to look externally to the knowledge segment of the template. This focuses firstly on ideas and then knowledge. A process orientated innovation tends to develop from senior management ideas which then require an understanding of internal knowledge across the organisation. Customer orientated organisations can also innovate through external knowledge orientation but are more likely to examine internal knowledge and competencies to work in collaboration with customers. This requires an understanding of internal knowledge/competencies to develop possible solutions to customer requirements. Senior management's support influences ideas internally often through position and power but more importantly gathered information shows the project is feasible and external ideas that may support the project. As the network develops given internal strategic decisions it must have a broad external orientation with as many choices in different template segments as possible. These should relate to the organisation and its current business but also to its strategy that may be orientated towards current technology but also future technology. An example being customers at SUA and WEL or in OCL's case the use of conferences and trade shows to examine developing technologies.

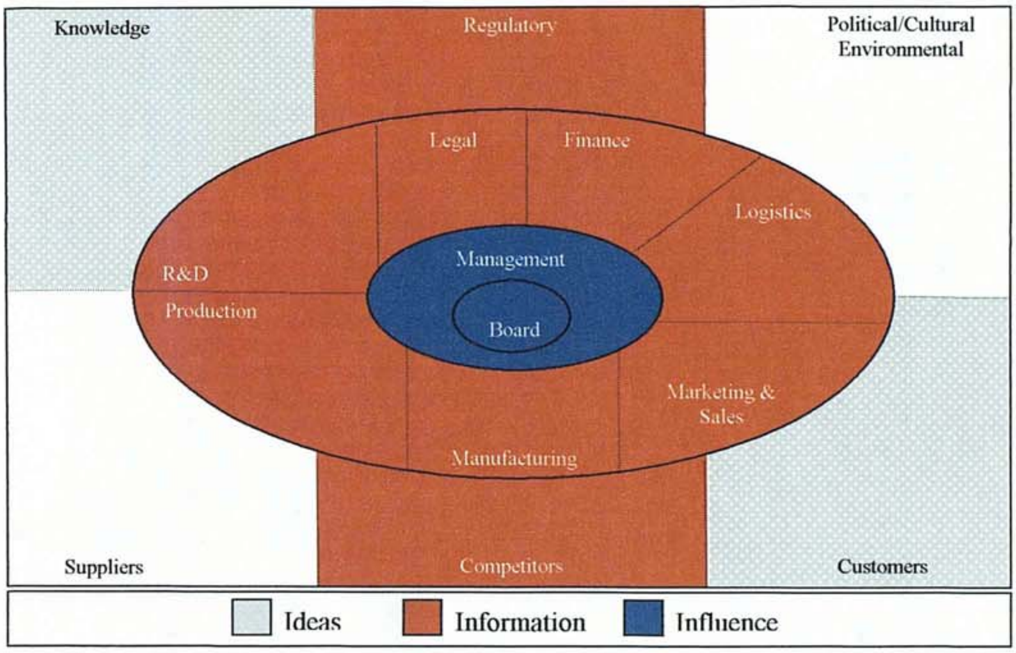


Figure 9.1: Network Stage 1 - Feasibility

Stage 1 (Figure 9.1) shows the initial network transactions required to access an idea or technology that improve competitiveness. External actors can play a key role at this stage. However, internal ideas and influence can also lead to the development of new ideas that may prove innovative. External areas of knowledge such as customers are most likely to generate ideas that lead to innovation. Especially in relation to mid-corporate firms with limited resources where customers and entrepreneurs supply many of the ideas. Management of this process is fundamental to the development of an innovation network. Early feasibility studies begin to answer the question of whether a project has the potential to move to the next stage. The influence of senior management will dictate whether such ideas are taken any further in relation to the feasibility study. Hence, as seen in Figure 9.1, internal information and to a limited degree knowledge are crucial at this stage. The feasibility study team must be able to access and be aware of information, knowledge and ideas within the organisation as well as externally.

9.4.2 Network Stage 2 - Formalisation

The next stage is formalising a network of actors with the competencies/skills and knowledge to begin development work on the technology. Where technology is involved the tendency is for organisations to look to the left segments of the template to find answers or possible solutions to the acquisition of a new technology. The network illustrated below is similar to that which formed the basis of OCL's TMS project way back in 1992. External knowledge playing the key role in the formalisation of the network initially involving key managers with understanding of the competencies and skills required.

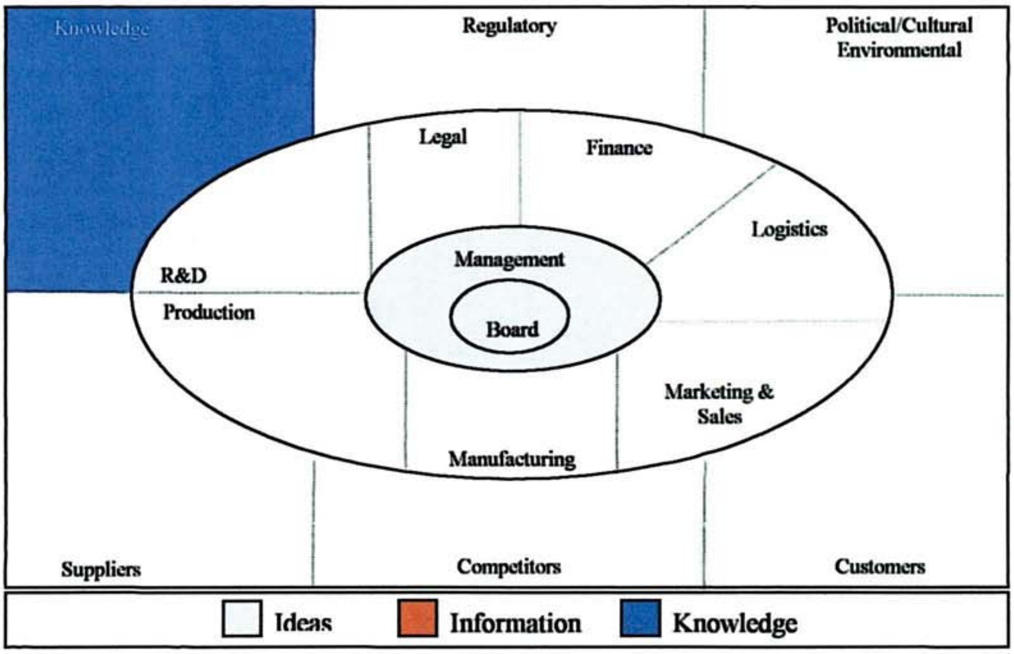


Figure 9.2: Network Stage 2 - External Competency/Knowledge Focus

Its main customer influenced SUA's project however the external orientation of the network to access technology was limited. The company in the case of the Air Assist Fuel Injection technology had the internal competencies and capabilities to develop the technology.

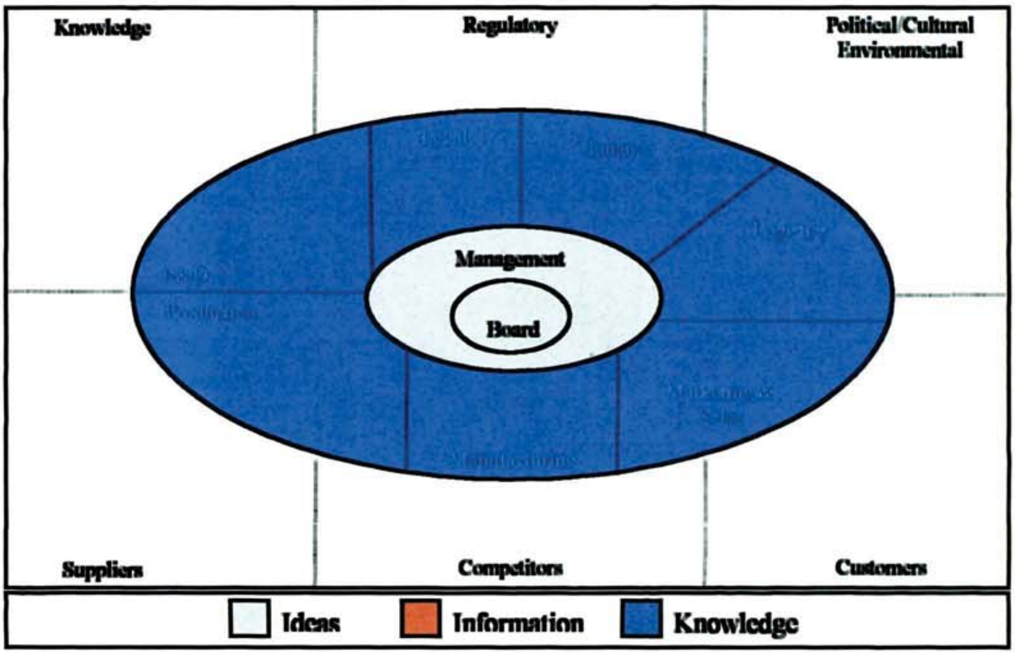


Figure 9.3: Network Stage 2 - Internal Competency/Knowledge Focus

The other companies looked to universities and external bodies to aid competency development as well as to suppliers for artefacts. However, in all cases the link was to either external knowledge, competencies and information or internal knowledge, competencies and information. Internal competency focus appears to occur where a development is customer based and tends to develop incrementally. External competency focus occurs when the new technology is further removed from current in-house technology and skills. Examples of internal competency focus were SUA and DDL where as external competency focus was viewed at OCL. There is a middle ground which is based on balancing internal with external competencies and DFM and WEL can be categorised in this way with external and internal competencies pulling together to achieve project aims and goals.

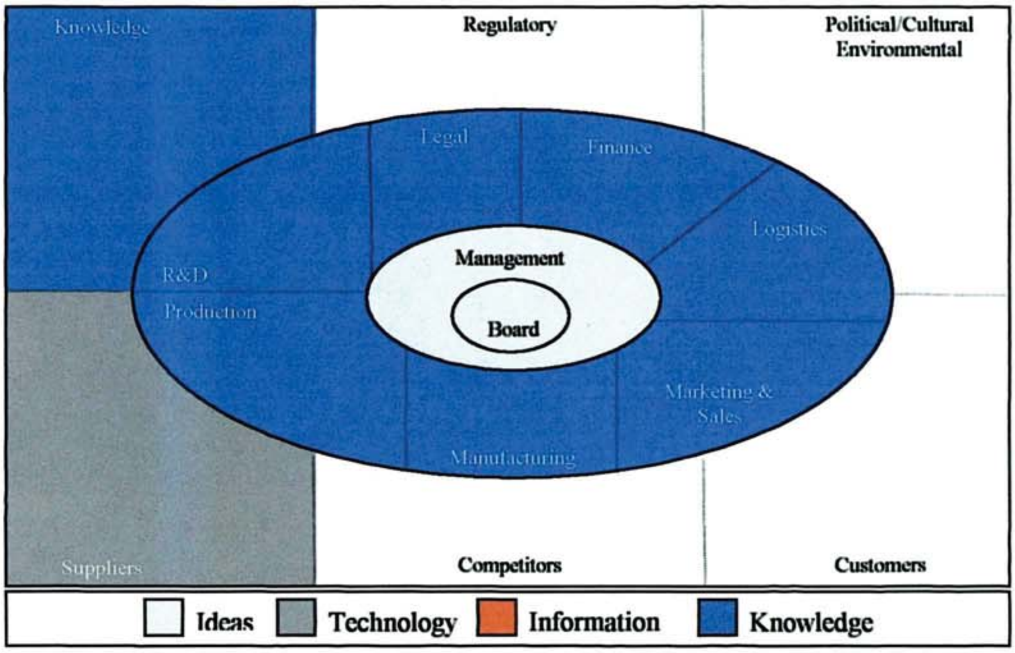


Figure 9.4: Network Stage 2 - Internal/External Competency/Knowledge Focus

Figures 9.2, 9.3 and 9.4 illustrate the network options that senior management have open to them at this stage. These options are informed by Network Stage 1 and the strategy type being followed which provides the basis for whether the project can be achieved internally, externally or a mixture of the two. Figure 9.2 would most likely follow a Type 3 strategy, Figure 9.3 fitting a Type 1 strategy and Figure 9.4 a Type 2 strategy. This assumes that the market has been identified and resources are potentially available and that the project is in line with strategy. Knowledge is vital to all three options. However, the network must have the ability to internalise the knowledge through competency development. Where external actors are being accessed to provide technology, knowledge and information that may lead to a potentially innovative product or process the boundary spanner or gatekeeper will play a vital role in choosing and formalising the network to include the correct set of actors. When setting up the network the choice of project manager/gatekeeper is critical otherwise Network Stage 3 will fail.

9.4.3 Network Stage 3 - Internalisation

This stage in network development involves the internalisation of knowledge. In the case studies the internalisation included the development of champions to co-ordinate training and learning to all individuals (DFM and DDL), the hiring of skilled actors (OCL and DFM), combining internal and external competencies/skills and knowledge (SUA and WEL). This stage is particularly difficult because incorrect decisions can lead to the possibility of failure (OCL for example). First by collaborating to access technology and competencies and secondly by internalising competencies through the hiring of new skills. Network stage 3 is the ideal point for a firm's strategic decision-makers to decide whether the project/development should be formalised to the point of full development and ultimately manufacture. Both external and internal individuals can be influential at this point in terms of the complete formalisation of the project/development. Internal actors are most valuable in Type 1 strategies and external actors in Type 2 and 3. However, a balance between both is key to all three strategy types.

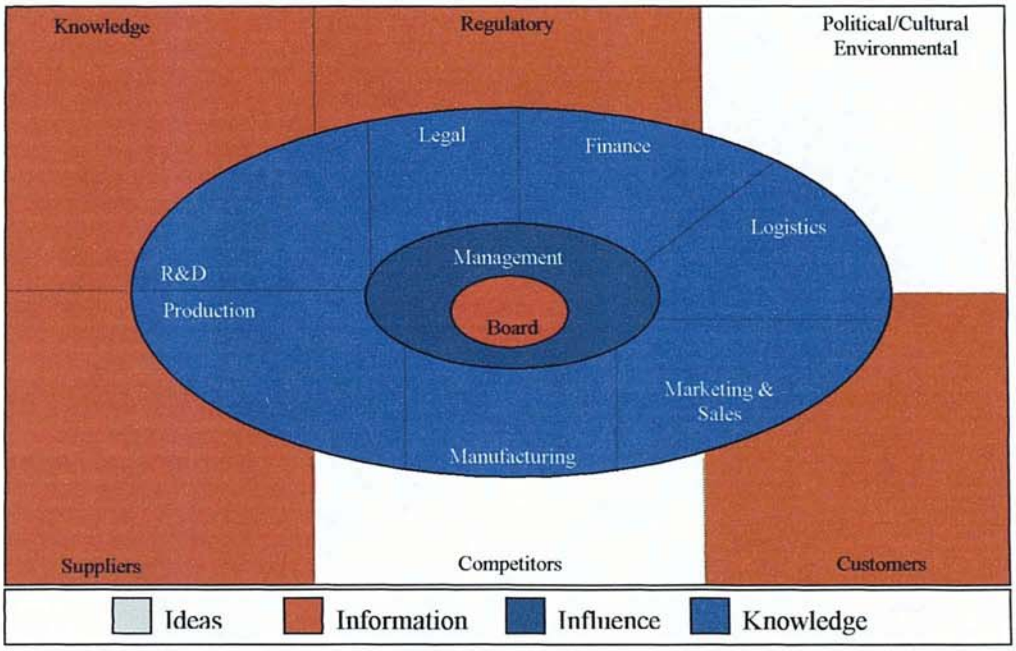


Figure 9.5: Network Stage 3 - Internalisation

The map for Network Stage 3 (Figure 9.5) shows the centralisation of knowledge to aid internalisation and learning. This is the period when the key project players need to make a decision on all available information externally and all knowledge that has been internalised. This stage is influenced by the knowledge, technology and information gathered in the previous two stages. All the case companies did this to a degree. However, as seen with OCL, customers in the early stages were ignored although possibly for the first time in DFM history customer benefits were being considered in relation to process changes.

Actors must, at this stage, transfer their knowledge within the innovation network and where possible within the organisation. Information from external sources will be high but the key for boundary spanners, gatekeepers and even internal champions is to decide the value of the information. The network objectives and strategic requirements will aid the value judgement. Hence why the gatekeeper is a crucial figure whether the project is heavily externally or internally focused. Whichever of the options in Network Stage 2 was chosen the external environment is still critical and information and knowledge will still be valuable.

9.4.4 Network Stage 4 - Functional

After the internalisation stage a period of consolidation occurs in terms of forming broader networks including functional activities such as production, engineering, marketing and operations. These functions did at times come into play earlier (process innovations) in the innovation process as seen during Network Stage 1 the feasibility period. Thereafter they play an important role in the internal cohesion and strategic decisions being made by the project network. There are two particularly good examples of this: the OCL network was very technology driven up to 1996, however, the new network identified the value of developing a market orientation. SUA had a more formal process for network development but as engineering and R&D functions had completed their elements of the project the network turned to the broader organisational areas for the design and development work to the customer through manufacturing, production and logistics. Also it should be noted that both SUA and DDL identified a general weakness in the direction of marketing to develop new markets and products. This stage also sees a clear consolidation with suppliers of materials and technologies in order to progress the project to manufacturing.

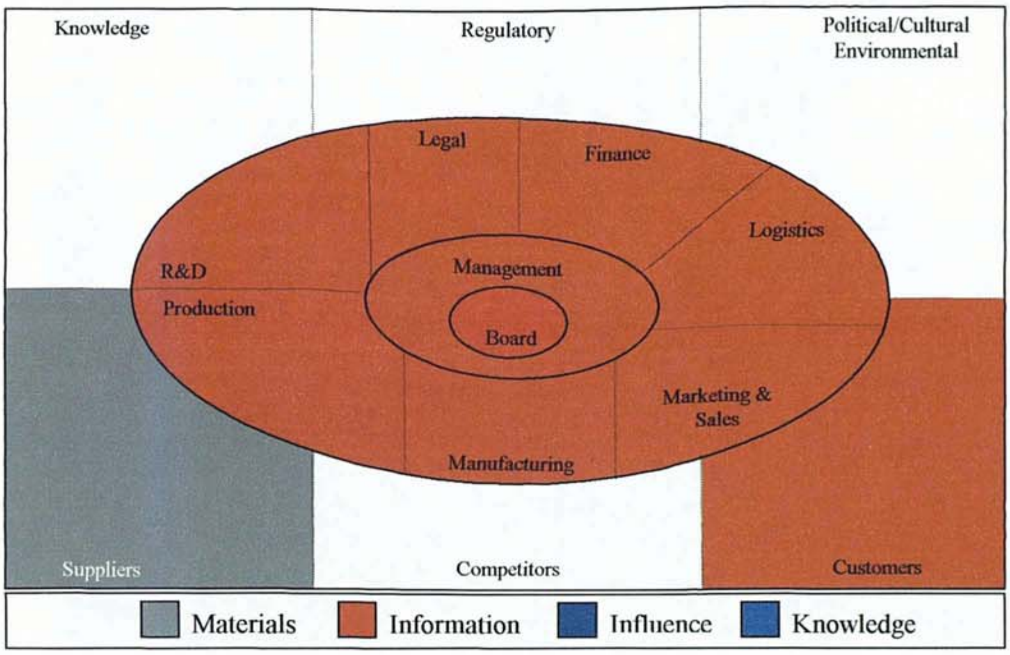


Figure 9.6: Network Stage 4 - Functional

Figure 9.6 shows the map for Network Stage 4 of the innovation process that involves all the key internal departments and actors required to achieve internal strategic cohesion through sharing of information. This stage leads to the completion of the project in terms of prototype manufacturing and testing for final product. This stage continues to involve marketing, production, manufacturing and possibly R&D/Technical where minor changes are required. Information is crucial at this stage. Transactions are readying change to tangible goods rather than information and knowledge hence the suppliers.

9.4.5 Network Stage 5 - Operational

This final stage occurs with the decision to begin manufacturing. The project is finalised in terms of the customer/markets distribution, tooling and manufacturing decisions made in Network Stage 4 are formalised. Manufacturing and logistics are the main internal actors with agreements on final delivery of manufactured goods to customers and distributors. This means a clear defining of material deliveries from suppliers. For product innovations this is likely to be the final stage in the network process however for a process innovation it is not inconceivable that further developments in the network may occur especially in the case of internal change. This is clearly the case in relation to DDL and DFM where internal process changes and developments are ongoing. There is likely to be a return to Network Stage 3 and 4 in order to address further changes and internal process developments.

Figure 9.7 shows the map for Network Stage 5 of the innovation process where the manufacture and supply of the product to customers or distributors is vital. This requires customers supplying information of order requirements and suppliers supplying required goods and technologies to produce the finished article. At this final stage logistics and manufacturing are crucial to meeting customer /distributor deadlines and therefore the sharing of information regarding status and requirement is crucial (see SUA case).

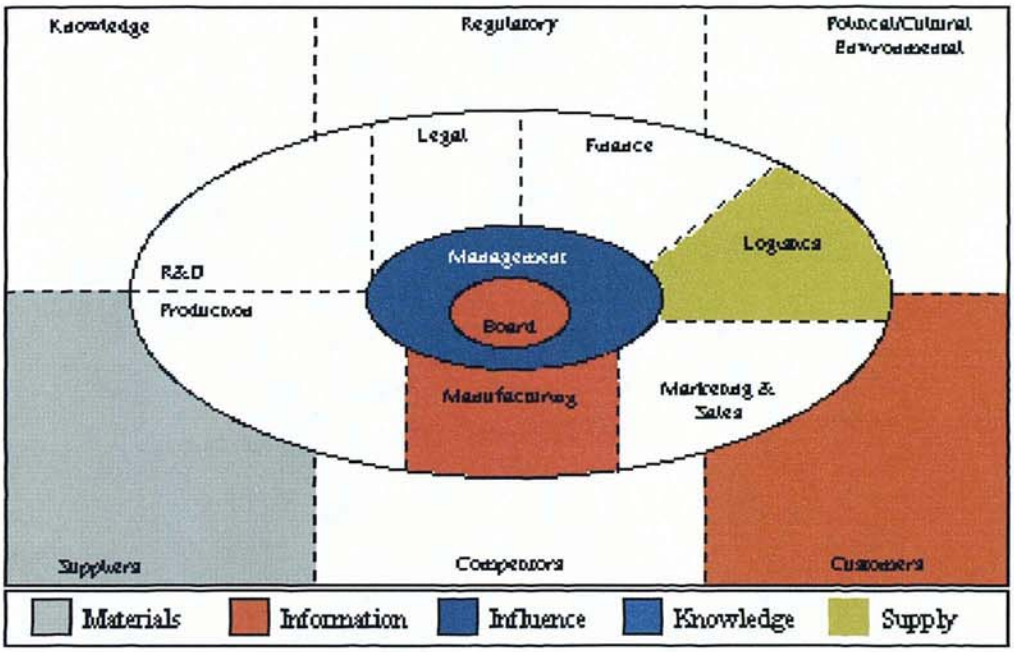


Figure 9.7: Network Stage 5 - Operational

9.5 THE SIN VARIABLES AND NETWORK STAGES

Each network stage involves a combination of variables to assist in the development of the innovation project. Each case was examined in terms of five specific network variables (size, openness, centrality, diversity and shape) and in terms of variables such as reciprocity, multiplexity and formalisation in relation to internal strategic cohesion and external orientation. These variables provide a set of choices of how firms should or should not approach each network stage identified.

- Network Stage 1 - Feasibility: No matter which corporate/technology strategy is being employed a firm must have options to access information, knowledge, current, new and future technologies as well as ideas to meet strategy needs. Therefore diversity of both internal and especially external actors is invaluable. The feasibility stage requires an open network that has a diverse external orientation to provide a myriad of external opportunities as well as market and environmental information. Centrality of the initial network is important to develop the project on the basis of corporate and business strategy and to ensure a strategic fit with the organisation as a whole. High external and internal multiplexity (multiple role relations) will ensure the gathering of information, knowledge and ideas can be achieved in a way that will assist the feasibility study and decision-making process. The communication process (reciprocity) must be bilateral and will on the whole relate to information rather than goods or artefacts. However, the information may relate to possible goods, technologies that could be accessed and utilised.

- Network Stage 2 - Formalisation: Formalisation of the network relating to a project that has specific aims and objectives both in terms of organisational and market value. Formalisation of individuals in the network is crucial in developing the links and flows between actors both internally and where possible externally. At this stage the network may take on three forms: internal competency focus, external competency focus or internal/external competency focus. These will depend on the strategy, the project driver (internal/customer), technology, the organisations internal ability, skills and the external opportunities. If the firm is developing competitive advantage through current technologies internal multiplexity should be high as in SUA. Reciprocity should be bilateral to share knowledge, information and technologies to develop products. Where the strategy is focused on new technologies the firm will need to increase external multiplexity and the network will focus externally as in the case of OCL. Reciprocity will be bilateral in terms of information and knowledge although in a situation where there is collaboration or strategic alliance the access is likely to be technology. Openness of the network will need to be high to gather the correct information and knowledge given the project. The centrality of the project networks will be high as all the cases outlined utilise some form of boundary spanner/manager (Tushman and Scanlan, 1981) whether internal or externally focused to deal with the information and knowledge and make decisions on the direction of the project.

- Network Stage 3 - Internalisation: As in Network Stage 2 the multiplexity of the boundary spanner and internal and external actors is critical to the continued project success. At this stage it is most crucial in relation to taking advantage of external actors and bodies by way of combining and internalising (Nonaka et al, 1996) information and knowledge. Openness and multiplexity assist in the success of this situation. A good example being DFM where knowledge from external sources was internalised through Bill McKenna and his relationship with module champions. Mulitplexity allows the learning and internalisation of the knowledge to spread through the organisation. The multiplexity aids in embedding the project network within the organisation. Reciprocity between the external bodies, actors, groups is likely to be unilateral in favour of the network with the most likely transaction being knowledge or information to support technology being developed. Centrality in terms of Board participation tends to lessen at this stage although in all cases the project leader/manager invariably updates and informs on a unilateral basis, more often that not, the Board and senior managers.

- Network Stage 4 - Functional: Accessing technology to support and develop a strategy for cultivating new as well as current technology. The focus of the network, if not already internalised, shifts to internal departments of the organisation. In doing so the internal multiplexity increases whilst external multiplexity tends to decrease. Focus shifts to suppliers and internally on logistics, materials, tooling and transferring the research and development into a product or organisationally orientated process. The project leader acts as boundary spanner linking individual functions or departments and co-ordinate the processes involved in transferring from research or development work to a broader production and manufacturing orientated network. Mulitplexity is high between the project leader and the individual actors and meetings will bring the departments together creating a situation for bilateral (reciprocity) transaction of information flows. Openness can be vital at this stage as information flows need to be honest to achieve success.

- Network Stage 5 - Operational: Involves a reduced number of internal actors with increasing supplier inclusion. The project leader co-ordinates the internal manufacturing, engineering, production, purchasing and logistics departments to meet the final customer deadline. The cases show that centrality is generally low as the links to the strategic decision makers is reduced with any link being unilateral from the project leader to the senior managers (e.g. OCL, SUA or DFM). Although the internal actors reduce the multiplexity for these actor groups is still medium to high with suppliers and distributors as well as individual customers (see SUA case) or the market (see OCL case). Reciprocity tends to involve information internally and materials and base technologies externally.

Table 9.5 summarises the variables required for a potentially successful dynamic innovation process based on particular technology strategies. Each network stage is organised in terms of development and relationships that should be attributed along with the types of variables that should be utilised.

Network Stage	Network Stage 1	Network Stage 2	Network Stage 3	Network Stage 4	Network Stage 5
Basis of Network	Feasibility	Formalisation	Internalisation	Functional	Operational
Networks Utilised	Internal Information/ Knowledge Network External Knowledge Network Customer Network Strategic Internal Network	Knowledge Focus Network Internal Focus Network Internal/ External Focus	Information Networks Internal Strategic Networks	Supplier Networks Internal Networks Customer Networks	Supplier Networks Internal Networks Distribution Networks
Relationships	Information Ideas/ Technology Ideas/Influence	Knowledge Knowledge/ Ideas	Information Knowledge	Materials/ Base Technology Information	Logistics Materials Information
Variables	Centrality - High Multiplexity Internal/ External - High Reciprocity - Bilateral both internally and externally Formalisation - Low more informal Openness - High internally Diversity - High externally to provide options	Centrality - High though boundary spanner Multiplexity Internal/ External - High Reciprocity - Bilateral both internally and externally Formalisation - Increasing for actors Openness - High internally and externally through trust Diversity - Medium internally High externally given decisions made and market.	Centrality - Medium Multiplexity Internal/ External - High Reciprocity - Unilateral external to internal Formalisation - High for internal actors Openness - High internally through meetings Diversity - High internally to learn and develop competencies.	Centrality - Low Multiplexity Internal - High Reciprocity - Bilateral internally Formalisation - High for internal actors Openness - Medium Diversity - High with suppliers	Centrality - Low Multiplexity Internal - High Reciprocity - Bilateral internally Formalisation - High for limited actors Openness - Medium Diversity - Medium internally although High with suppliers.

Table 9.5: Summarised Network Stages

9.6 THE SIN FACTORS AND NETWORK STAGES

The examination of the network stages in relation to strategy also suggests that the five factors identified by Dodgson and Rothwell (1991) and integrated into the SIN framework require the use of different networks. This was partially discussed in Chapter 4 when developing the SIN framework where I argued that each factor required a particular network orientation to achieve its strategic objectives. Each proposition is identified below and discussed:

- externally orientated networks may be utilised where competencies and skills are lacking

This first proposition is supported by Network Stage 2 developing three possible options to orientating the network in order to access required skills, resources and competencies. In aiming to develop its electronics competence OCL orientated its networks towards the knowledge segment of the SIN framework. In general external networks are used to access knowledge.

- where internal strategic cohesion is valued then communication between divisions and functions as well as with senior managers will be shown by the SIN framework - the greater the internal strategic cohesion the greater the actors internal links and flows

In terms of internal strategic cohesion both DFM and DDL confirm the value of strong internal communication to develop internal processes and evolution of the systems developed. In both cases internal strategic cohesion is vital and the flows of information and knowledge are high. The communication of information is a key element of this factor and relates strongly to Network Stage 3

- management skills are likely to influence the network shape and the actors chosen for the innovation process

Management skills affect the cases in different ways. SUA's network and shape were determined by very specific procedures that require particular skills and competencies. All the project managers had skills that influenced the networks including OCL which was identified when Graham Kennet took over the TMS in 1996. His influence led to the increasing orientation of the network to the market and potential customers. Network Stages 1 and 2 are orientated by this factor.

- the types of external links are likely to be influenced by strategy e.g. to develop future technology then a mid-corporate firm would be best placed to utilise and orientate actors towards the knowledge segment of the SIN framework

In identifying that corporate/technology strategy directs the type of networks and the fact that different strategies access different technologies then we can conclude that external orientation will be influenced by strategy. In the case of OCL new technologies were being developed that required the external orientation of networks towards actors that had competencies and technologies that might be internalised. WEL on the other hand aimed to access technologies that would allow current technology to be developed for the future. In creating the NPD Committee WEL developed a network that during the research concentrated on accessing to particular external key technologies. Network stage 3 is most influenced by this factor.

- the relationship between the development and strategy may affect the embeddedness of the network within the organisation.

The degree of embeddedness and value a particular innovation may have to an organisation is highlighted by the DDL and DFM cases. Organisational specialisms such as operational processes and systems formed the basis of the software developments in the two cases. Even in the case of OCL the network in the early stages of the innovation was a major part of the organisation's specialisms (electronics/sensors). However, at the later stages of the TMS project at OCL communication beyond the TMS department was extremely limited. WEL on the other hand developed a new product development committee to bring new products closer to the strategy as well as the market place. The NPD Committee was clearly developed on the basis of strategy but also on the markets in which the organisation was embedded. This factor affects all the network stages due to the systems and communication required throughout the innovation process.

9.7 THE NETWORK PROPOSITIONS SUMMARISED

The stated aims of the research were to identify the dynamic innovation process from a strategic network perspective and to identify the relationship between strategy and network structure. To achieve these aims a number of propositions were developed. In this chapter I examine whether strategy leads to particular networks. In doing so I look at the product and process innovation debate in relation to the SIN framework to highlight the differences between theory and practice. Finally the chapter examines the network stages identified in the innovation process and how and why these vary over time providing a dynamic network element to the innovation process.

The discussion began by examining the strategies undertaken by the case study organisations. Each organisation was analysed in relation to the framework identified by Itami and Numagami (1992) and utilised by Berry and Taggart (1998). The three strategy types relate to current and future technologies and the way in which strategy drives technology. There are very clear differences between the organisations in terms of their strategic approaches. However, by defining the strategies I was able, with the network framework, to map the networks on the basis of strategy types. I show that the strategic type influences the network types. For example, DFM and DDL both developed Type 1 strategies and in doing so were internally focused with their networks based on internal knowledge with limited supplier networks. SUA and OCL aimed to develop a Type 2 strategy with the two cases involved in internal knowledge and innovation networks with external knowledge networks based on external knowledge actor, customer and competitor information playing an important role. Finally, WEL was aiming for a Type 2 strategy which borders on a Type 3 with a very strong external orientation to its internal strategic network cultivating new technology and attempting to drive current and future strategy. Therefore, distinct differences in network types were seen to achieve particular strategies.

An examination of product and process innovation shows that the choice of either as a source of competitive advantage does influence the general type of network form. It also shows that the theory on product and process innovations and the organisational frameworks that assist in achieving either are not as clearly defined as they might be. Process innovation is more internally focused and driven through internal networks and although product innovations tend to be driven by external factors contributing to the decision making process such innovations and their corresponding network can be very internally focused. This may have some affect on success or failure. The choice of corporate strategy and possibly business strategy in the cases discussed dictate whether an attempt at innovation will be product or process driven. As I have shown the choice of product or process will influence the network type utilised during the project and its development.

There is no doubt that the innovation process is dynamic. In the discussion I identify five key network stages in this dynamic process. Each of these five network stages vary between cases due to the strategy being followed. The network stages show a definite development in network orientation and shape over time. Hence each network stage may vary in terms of network type or types. These differences are mainly due to the corporate/technology strategy but other influences include:

- the strategy type as already discussed
- current business situation
- the type of innovation - product or process
- the internal/external knowledge/information available (resources)
- actor resources
- senior management decisions

The influences are not mutually exclusive. Strategy appears to orientate networks in relation to technologies and how they are accessed and developed based on the resources available. Resources will be accessed internally, externally or more often than not through elements of both. Resources will influence the network shape over time. As seen with OCL that had a network externally orientated due to the initial corporate/technology strategy (early 1990s) and the fact that resources for such technologies were limited in-house. OCL also showed the power and influence of managers and Board on the network over time. The Technical Director influenced the continuation of the project by keeping it going to solve technical problems and hence strengthen the projects position in relation to the Board. The case also showed the influence strategy can have on a innovation network if corporate strategy changes during the development. DDL and DFM showed the value of internal resources in relation to process innovations. With such networks, even where external bodies are utilised to aid process changes, internal actors are key to achieve the desired objectives and benefits. WEL's innovation committee network, at the outset, was strongly influenced by the Board in order to strengthen innovative activity. A network was constructed to examine and access potential new technologies. Given the business, the network was clearly orientated towards knowledge and suppliers of technologies that could develop such areas. The same is true of SUA, innovative and network activity was driven by business requirements and market needs. The business strategy as part of the corporate strategy has influenced the project networks in relation to customers and technologies being developed. Such relationships between strategy and networks are also supported by the examination of the SIN factors and the network stages. The factors are influenced by strategy and therefore influence the network orientation and shape.

9.8 CONCLUSION

The development of the SIN framework has provided a major contribution to the SMOT literature. The SIN (Strategic Innovation Network) framework allows a perspective of networks in relation to the strategic management of technology. Network types such as strategic alliances or joint ventures can be examined not just at the level of the organisation or department but at the level of individual actors. The dyadic links are researched to examine the relationship between different corporate/technology strategies and types of networks used. The framework is also presented such that it may be used in a proactive manner to construct networks to achieve strategies. It also provides the means of analysis of current networks in order to re-organise new network possibilities given a re-orientation in strategy.

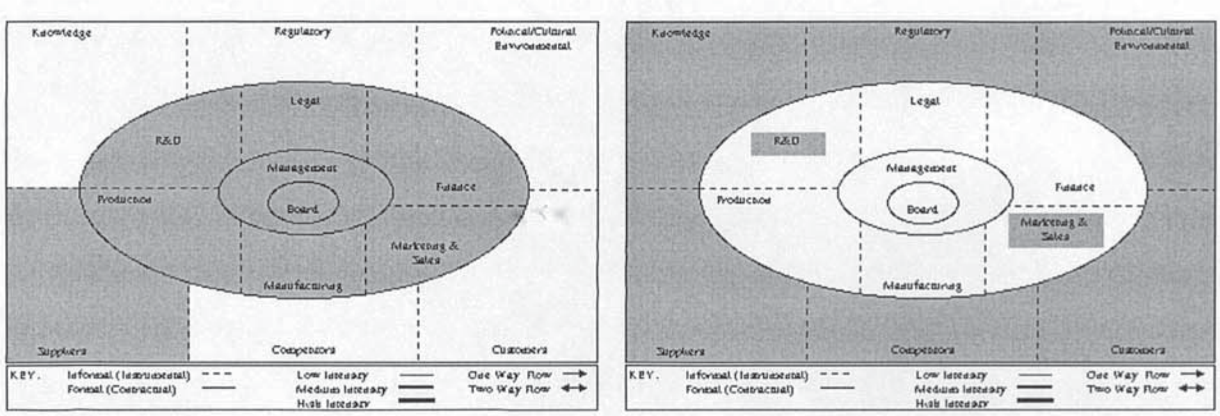


Figure 9.8: SIN orientation for process and product innovations respectively

I have also been able to show that product and process innovations lead to very different network orientations to achieve the strategic objectives. Again suggesting that innovation strategy (product or process) effects the networks developed. The orientation of such innovations is summarised in Figure 9.8. The shaded areas show the key network segments that must be considered to access actor and relationship types that may benefit the innovation these are not static but evolve over the period of the innovation process.

The title of this chapter is 'Dynamic Technology Strategy' this was chosen to encompass the value of the framework utilised. The SIN framework combines key elements of the innovation process (i.e. technology strategy, networks, resources and environment) in order to understand the dynamic relationship between them and the goal of innovation. In examining the evolution of the innovation process from a network perspective I identified five key dynamic network stages. These network stages (feasibility; formalisation, internalisation, functional and operational) and the network types utilised are shown to vary with corporate/technology strategy (e.g. Network Stage 2: Formalisation (b) follows Type 1 strategy). This supports the conclusion of the Chandlerian thesis (Chandler, 1962) and my proposition that network structures follow corporate/technology strategy. This is based on an analysis of traditional mid-corporate firms undertaking a new corporate/technology strategy to achieve a particular innovation. However, the research does suggest that the relationship is true in reverse as the organisations move to a Type 3 strategy (Itami and Numagami, 1992). The technological development and therefore the networks ultimately influence the Type 3 strategy and as stated on page 338 the use of certain networks can influence strategy decisions. The idea that strategy is not independent of structure is supported by Jones et al (2000). Jones et al (2000) utilise structuration theory (Giddens, 1984) to understand the innovation process. The cases identified in the paper, including OCL, viewed 'communication' as a key cause of strategy failure because of particular internal structures. These structures and their apparent failure led to a change in strategy and structure. Jones et al (2000) state that 'structure underpins the way in which agents make sense of, and organise their actions.' This suggests that managers' (agents') decisions are also influenced by the structures in which they operate and relate. Routine patterns of behaviour are also identified as unintentionally reproducing particular structures. However, the degree of innovation can lead to a modification or replacement of routines and behaviour which therefore can create new structures (Jones et al, 2000). This discussion shows that strategy and structure are intimately linked and strongly suggests that although strategy influences structure it may also be influenced by structure. The literature suggests that if the thesis had begun by examining what led to each strategy choice then structure may have played a key role. Figure 9.9 summarises the network stages discussed at length in section 9.4. Each of these network stages highlights the network choices available to achieve the technology strategy.

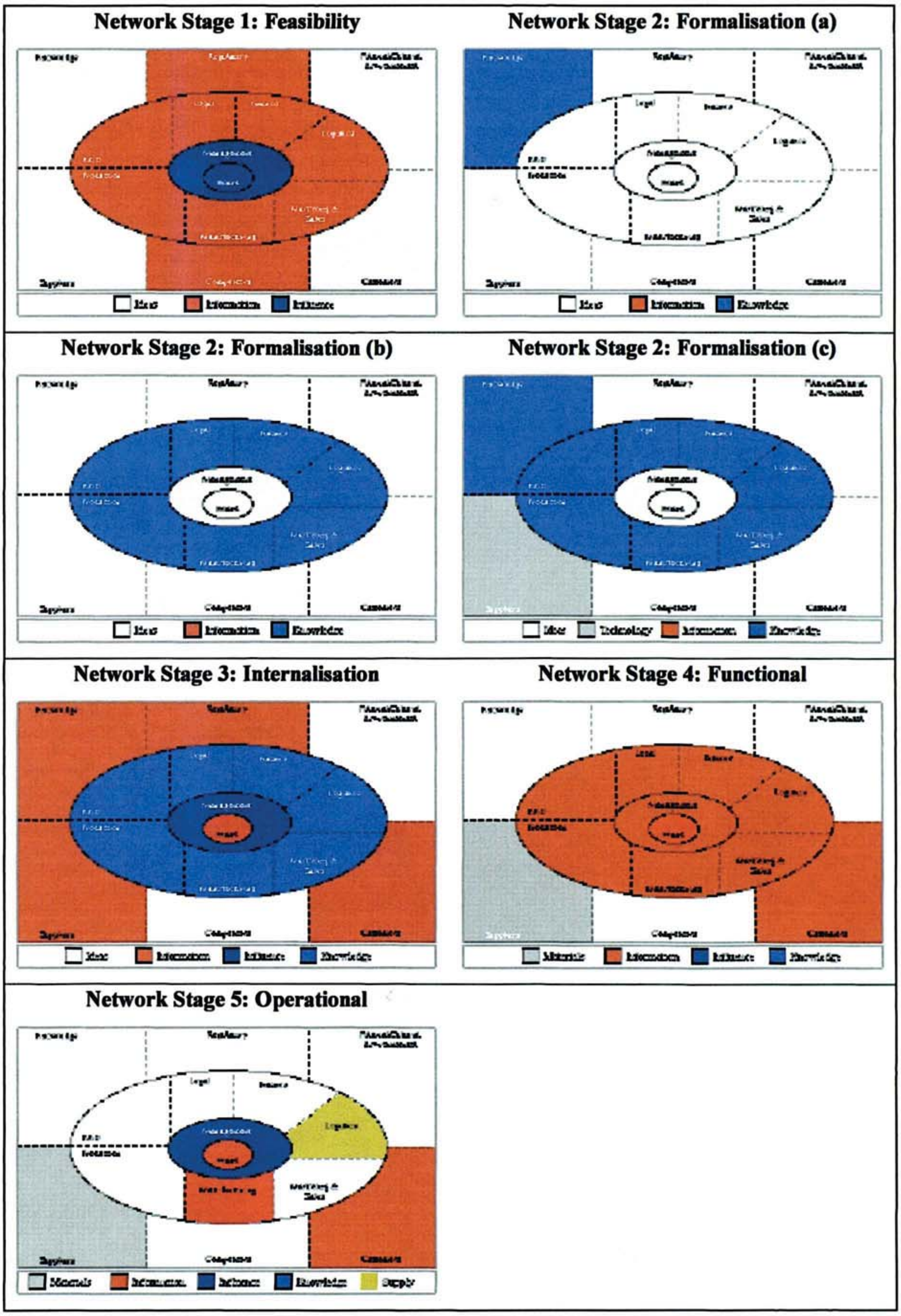


Figure 9.9: Network Stages

The analysis of the cases has shown that strategy (corporate/technology) relates to particular network types and that resources are key to both. Resources impact on the networks formed and the strategy chosen. Actors play a major part in the networks from a resource-based point of view. Strategy orientation is also linked strongly to the choice of skilled resources available both in-house and externally thus impacting on the network orientation. The five Dodgson and Rothwell (1991) factors that underpin the SIN framework also show the impact strategy has on the network types. If the technology strategy requires the development of technological competencies then, once these are identified, the first step would be to orientate internal management and technologists towards the knowledge segment of the framework. Other external networks (customer/supplier networks) can also assist in this technology strategy requirement. Network types will aid in achieving the various Dodgson and Rothwell (1991) factors. Using the framework I have also been able to show the impact, both good and bad, the innovation networks environment can have on its ability to operate. With the environment being both a driver for innovation (SUA and DFM) but also a barrier or at the very least slowing the process down both from a market perspective (OCL) as well as a network perspective (OCL and DDL). The innovation process is viewed as highly dynamic and suggests that particular innovations are influenced by the strategy. As strategy changes and evolves then so do the networks that exist to achieve innovation and organisational technological change.

Chapter 10: CONCLUSION

CHAPTER 10

CONCLUSION

10.0 INTRODUCTION

The thesis began with the question - To what extent do networks contribute to the strategic management of technology? This led to an examination of the SMOT literature in relation to network perspectives. An examination of the specific network literature aided the understanding of networks and their functions. This aided the development of a network perspective for the strategic management of technology. The SIN framework was then utilised to examine a set of propositions and ultimately identify a dynamic innovation network perspective. Therefore the framework contributes to the strategic management of technology literature and provides potential for future research.

10.1 SMOT

Chapter 2 discusses the management of technology, defining technology and innovation and then develops this perspective into the strategic management of technology. I discuss the levels of strategy that underpin the strategic management of technology based on the work of Coombs (1994). These levels of strategy (corporate, business, technology, innovation and R&D) show that technology is an integral consideration throughout the strategy process. This is especially so in SMOT theory where technology has a strategic place in the decision-making process of all firms whether large or small, high-tech or low-tech in order for them to stay competitive. Technology strategy is viewed as highly dynamic and an integral part of the corporate strategy. Berry and Taggart (1998) state that the key to a technology strategy's potential success is stimulating and developing competitive advantage through its integration with corporate strategy. For the purposes of the research the Itami and Numagami (1992) framework was used to identify three types of strategy relating to technology and corporate strategy. Strategy choices at any level are complex and involve significant if not infinite variables. Practically, for the purposes of the research a simplified model was chosen on the basis that it was significant to small firms that were to be studied. In summary the strategic types are:

1. Current strategy capitalises on current technology - this focuses on the matching of a firm's chosen corporate strategy and the current technological competence of the business.
2. Current strategy cultivates future technology - if the first is achieved then the likely hood is that technological accumulation will occur providing the firm with the potential for the future over and above current technological developments.
3. Current technology drives cognition of future strategy - the writers suggest that a firm's current commitment to technology and technological development will inherently influence management's perception of the firm's future strategy.

10.2 SMOT AND NETWORKING

The examination of the strategic aspects of the management of technology highlights the way in which SMOT has been researched and examined in the last 20 years. The examination of the SMOT literature identifies the contribution of networking to the field. The contribution of networking to the SMOT literature has been almost non-existent from the following perspectives:

- individual network actors
- network mapping
- innovation process
- SMEs

The SMOT literature concentrates on joint ventures and strategic alliances at the organisational level (or inter-organisational level rather than intra-organisational level) to provide a network perspective. Such an approach lacks a network analysis or examination in terms of social network theory (Burt 1992; Mizruchi, 1994), mapping (Conway, 1997) or network variables such as links, flows, transaction content (Kanter 1972). However, relationship types have been viewed as a valuable decision making variable when entering a strategic alliance (Gulati, 1998; Dussauge et al, 1987). Rothwell (1994) identified innovation as having a number of generations. The current fifth generation identifies networking as a key component. However, it has only been since 1997/98 that the element of networks has been taken seriously in the innovation process and the SMOT literature with research by Gulati (1998), Ford and Thomas (1997), Conway (1997), Doz & Hamel (1997). However, even in these new developments in the strategic management and innovation areas the focus is the organisation and not the individual actors and SMEs tend to be largely ignored as they have been generally throughout the network and SMOT literature (see Dodgson & Rothwell, 1991; Conway, 1997). Hence, the thesis concentrates on SMEs or mid-corporate firms and the individuals that play a role in joint ventures and the innovation process. The Dodgson and Rothwell (1991) five factor framework utilised to understand the strategic management of technology processes clearly views networking as important to the overall process but fails to develop this particular aspect.

10.3 NETWORKING

Chapter 3 examines the literature to identify what networking is and how it is dealt with from a social perspective and innovation perspective. More importantly how networks may be defined, utilised and their value in understanding the processes behind the management and strategic management of technology. The list of network types developed in the chapter is not an exhaustive one. The types identified, from informal and formal to knowledge networks, do have some generic terminology and include other types of networks that assist the networks functioning. Clearly, the types have definite functions that in particular ways may aid the strategic management of technology and innovation process. In examining the network literature Grandori & Soda (1995) utilise a framework which indicates that network types fit into three particular categories. Each category has a distinctly different network perspective: social networks; bureaucratic networks; and proprietary networks. I discuss the network types that fit these particular categories.

In identifying strategy and network types the strategic management of technology as a practice is left with a number of choices based on decisions that have to be made. It was therefore at this point in the research that I believed that a framework was required to examine the dynamic link between strategy choices and network choices.

10.4 ADDRESSING LIMITATIONS - THE SIN FRAMEWORK

The SIN framework addresses the network limitations of the SMOT literature. Both because of the lack of network content but also because the literature concentrated on departments and firms. Conway (1997) has developed network-mapping conventions to map innovation networks. In Chapter 4 I therefore examined the possibility of integrating this network mapping framework with ideas related to the strategic management of technology in small and medium sized firms. This integration provides the strategic management of technology with a network perspective that will allow researchers and practitioners alike to examine both partial and total networks involved in the SMOT process. The SIN framework as shown in Chapter 9 provides:

- a means of meeting many of the identified network deficiencies in the SMOT theory as well as network theory including: the examination of individuals in a network; identification of relationships, links and flows in SMOT; longitudinal analysis and network dynamics; examination of small firms/mid corporate firms; and the embeddedness of the firm, departments, and actors in their environment.
- a framework that analyses the SMOT factors from a network perspective
- a framework that aids the decision making process based on particular technology/ corporate strategies
- a dynamic examination of the innovation process and strategic management process

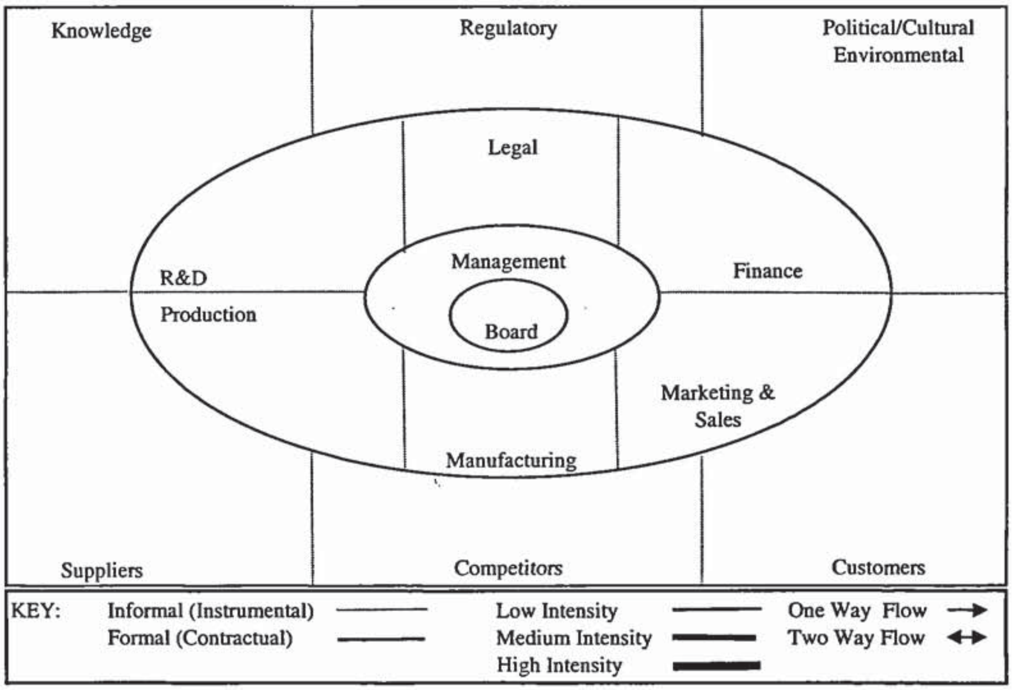


Figure 10.1: The SIN Template

The framework is flexible in the sense that the internal organisation of the firm can be changed depending on the firm and on changes in structure over time. Actors are mapped and positioned in relation to their function. Both internal and external actors are mapped. The relationships are given further diagrammatical detail by way of different lines linking actors and by use of colour to provide detail on the transactions. The framework was used to examine the propositions identified in Chapter 5 using the following methodology.

10.5 THE METHODOLOGY

The propositions were examined using a particular research strategy and the framework developed in Chapter 4. The research approach is based on case study analysis. Using the SIN framework to shape the case studies reduces many of the weaknesses identified with such methodologies. As Yin (1994) points out case studies are important in answering how and why questions but also in examining subjects on a longitudinal basis. A qualitative approach to interviews rather than using questionnaires adds the detail required in examining the networks and in answering key questions to carry out the analysis. The propositions focus the research on particular areas of the organisations being studied. For instance, the link between technology/corporate strategy and networks; projects or developments that aim to provide a product or process that is innovative. The why and how questions focus the research on the strategic management of technology factors in relation to the networks employed and by using the SIN framework over time the research shows how networking is affected by strategic decisions and by the inputs into that decision-making process.

Using a pre-prepared set of questions to interview each actor involved in the innovation network meant that time was spent in the field. Each actor, no matter which company, industry, position was asked the same questions. This provided a consistent basis for the data gathering but more importantly strengthened the longitudinal perspective of the research. By asking the same questions of all actors, on a number of occasions over a period of time meant that network changes and strategic management changes could be identified and in a way that did not bias the possibility of particular answers. The research period was 18 months with a minimum of six visits during that period to each case. This was dependent of the availability of individuals. For instance OCL was visited twelve times.

Such a study could have been undertaken through questionnaires and quantitative methods. However, such an approach would have failed to provide the detail required for examining the organisations, their strategies and networks. Qualitative studies tend to be packed with detail and although they can lack the ability to generalise particular situations they do provide a detailed examination of individual situations and contexts. These can inform the debate and generate the potential for broader research.

10.6 THE ANALYSIS

The framework provided a means to analyse strategy in the research organisations and in relation to the particular innovations identified in Chapter 6. Chapters 7 and 8 present the research findings of the case studies. Chapter 7 concentrates on two particular cases that are significantly different in terms of their approaches to innovation. Chapter 8 presents further cases to supplement and at times contrast the findings presented in Chapter 7. The SIN framework was used to map the key network developments in all cases. The number of maps varies depending on the case but each identifies changes in the network depending on project requirements as well as organisational requirements. Each map identifies actors and their links, flows and transactions based on the interview responses. The analysis is then developed in the final sections of each case by examining the cases and maps in relation to the five strategic factors that underpin the SIN framework. The network variables identified in Chapter 4 are used to examine and understand the strategic processes within each factor. The analysis identifies the level of strategy within each firm and the orientation of networks based on external orientation, internal strategic cohesion, accumulated technological competencies, organisational specialism and management skills. An examination of the propositions forms the basis of Chapter 9. Furthermore I develop the dynamic perspective of the innovation process from a network perspective and examine the propositions.

10.7 RESULTS

The analysis examines the product and process innovation theory in relation to the findings of the case studies. Using the case study analysis and the Itami and Numagami (1992) framework I identify the corporate/technology strategies employed by the 5 firms. This was done to link the networks mapped to the strategy employed. A Type 1 strategy was shown to utilises networks that are internally orientated. However, as a company attempts to move to a Type 2 or 3 strategy these networks tended to evolve towards external segments of the SIN framework and shows that gatekeepers are a key element in achieving this external orientation. The conclusion is that network structure follows corporate/technology strategy. The SIN networks support the literature relating to product/process innovations. The conclusion is that process innovations tend to be internally orientated in relation to networks whilst product innovations are externally orientated. The analysis of the case studies identifies a set of stages surrounding the innovation process showing an evolution of the networks. Five stages were identified with each stage showing that network orientation depends on the strategy employed. Finally these stages were examined in relation to the variables identified in Chapter 4. This showed that the value of particular variables depends on different innovation and network types. This provides a guide for strategic decision-makers in terms of how they should orientate the variables at each stage of the innovation process to assist the development. The use of the SIN framework to undertake the analysis allows a dynamic understanding of the effects of strategy on networking, the innovation process and the overall organisation. It is clear that networking and innovation is not a static process and depends on strategy.

10.8 MAIN CONTRIBUTION

The main contribution of the research is to provide a dynamic analysis of changing relationships, strategies and objectives during the introduction of new technologies and the innovation process. This initially began with the integration of a strategic approach to the management of technology with the concept of innovation networks. This was identified as a weakness of the literature by a number of writers (Gulati, 1998; Ford and Thomas, 1997; Conway, 1997; and Doz & Hamel, 1997) at the end of the 1990s. In general their approaches to this weakness have been based on specific elements of the SMOT literature: strategic alliances (Gulati, 1998); technology strategy (Ford and Thomas, 1997); technology strategy and organisation structure (Doz and Hamel, 1997). None of the above papers follow formalised conventions to understand the examined networks in relation to strategy. Conway (1997) however, does examine the innovation process through a set of mapping conventions organised around a template to map groups of actors and individuals. The problem with the Conway (1997) template and conventions is that it is best suited to examine external networks and their links to particular individuals within an organisation. Its limitation is its lack of developed conventions relating to internal network orientations and mappings. Therefore its use in examining the strategic management of technology from a network perspective in relation to internal strategic cohesion; communication and organisational specialisms are not dealt with. The SIN framework redresses this weakness. The SIN framework adds a SMOT element to Conway's (1997) template and strengthens the basis for analysis. The integration of two key frameworks provides a set of mapping conventions and variables. This gives a framework that provides a means of mapping networks, identifies variables to be researched from both a network perspective but also from a SMOT perspective, aids the structuring of the research and offers the ability to examine networks and strategy over time. The longitudinal approach used in this research provides a means to research innovation beyond the general static approaches as identified by Afuah (1998).

The framework was used to examine a set of propositions and the relationships between technology strategy, innovation types and network structure. The research involved case studies based on five mature mid-corporate manufacturing firms. Again this is an area that has been neglected in the literature (Chapter 2). The analysis initially examined the corporate/technology strategy of each case and using the set of SIN maps for each concludes that technology strategy affects the network approach. Depending on the corporate/technology strategy type (Itami and Numagami, 1992) being followed by each case then varying network types appear to be utilised and similar strategies use similar network types. A similar conclusion was found when innovation types where examined in relation to network types. The firms opted for either product or process innovations depending on strategy, and they were found to generate particular networks for a particular type of innovation. In terms of the cases product innovations were more likely to utilise externally orientated networks whereas internally orientated networks were process innovations.

As stated by Jones et al (1999: 2) research methodological approaches relating to organisational relations and networks have been dominated by cross-sectional, quantitative empirical studies carried out at the organisational level. Oliver and Ebers (1998) acknowledge that qualitative research is more likely tc reveal social phenomena but is under-represented in the field. The longitudinal and qualitative approach taken shows that an innovation network changes over time. The network takes on a number of forms depending on requirements, resources, strategic decisions, the environment and technologies. Changes in these will lead to changes in network shape, actors and transactions. The research shows that the innovation process evolves over time and as it does social dynamics change and a number of network stages develop. I identify these stages as: feasibility; formalisation; internalisation; functional; and operational. These stages take on different network structures depending on corporate/technology strategy. The innovation process therefore changes over time and is viewed as highly dynamic with the network structures employed depending on corporate/technology strategy. Unlike all the dynamic models of innovation[2] identified in Chapter 2 the SIN framework allows strategy to be examined in relation to: all individual actors; a single innovation; and therefore networks over time. Therefore the main contributions of the thesis are:

- the development of the SIN framework to examine and analyse SMOT with a network perspective
- the network types utilised to innovate follow the corporate/technology strategy employed
- to enable the examination of the innovation process from a network perspective
- the identification of five dynamic network stages to the innovation process dependent on strategy as well as resources

10.9 LIMITATIONS

A number of the limitations of this thesis are discussed in Chapter 5. There is no question that having a larger number of cases involved in the research would have provided the possibility for generalisation. A case study approach is viewed by some as a weakness in making substantive claims about research. As discussed in Chapter 5 generalisability of the research is seen as a disadvantage of this approach. Clearly the research propositions and results cannot be attributed to the whole manufacturing sector and the thousands of mid-corporate firms that exist. However, I would not be surprised to find that through future research many of the findings of this research would be replicated in a vast majority of these types of firms.

Integrating two theoretical concepts for the purpose of examining SMEs and mid-corporate firms developed the framework. The utilisation of the Rothwell and Dodgson (1991) framework, developed from SME and mid-corporate research, potentially narrows the contribution but allows for the analysis of organisations poorly dealt with in the SMOT literature. Large firms where not considered in devising the five factors to examine strategic management in firms. Therefore, I would not be prepared to state that the SIN framework could be used to examine strategy and structure and the innovation process in large firms. The

---

[2] Afuah's (1998: 335) Strategic Innovation Process offers a number of similarities to my network stages. His framework is based on the strategic management process (Hill and Jones, 1995). It identifies twelve systematic processes for strategy formulation and implementation allowing the company to profit from innovation.

variables upon which the examination is based may to some degree limit the analytical value in relation to strategic management of large firms.

Although addressing weaknesses of the SMOT and network literature and therefore dealing with SMEs and mid-corporate firms there is no examination of whether firm size actually affects the innovation process and therefore strategic innovation networks. Mintzberg's (1979) contingency approach suggests that organisational forms are contingent upon the state of certain variables. These variables are employed by the organisation and include: size; environment; and technical systems. Clearly size may well be a factor in determining not just the organisation but also the networks utilised to undertake innovation. Given the number of research sites involved in the study it would be impossible to test that theory. The study would require cases to be identical in terms of among others markets, technologies and products but vary in size.

In identifying the set of actors involved in each on the innovations in the way that I did may potentially have led to key actors being missed. Even with a 3 month window for network changes and time to undertake interviews it was still possible that actors may have been used informally to assist in that period and I may not have been made aware of this. This was found to be the case in the interviews of SUA. Changes in purchasing occurred frequently in the early stages of the project whilst new store procedures where being developed. These did not impact directly on the Harrier project in terms of its development but did mean that at least one informal actor was not interviewed. By the time the project leader had identified the actor he had left the company. It is not inconceivable that this could have happened with potentially key actors in other cases. Reliance on the project leaders may have meant that a degree of bias was created and the partial networks analysed were missing informal actors.

10.10 IMPLICATIONS OF RESEARCH

The thesis has aimed to develop the network perspective of the SMOT literature. In doing so it has raised a number of important issues for traditional mid-corporate firms and SMEs. The framework developed and the case findings I believe have implications for academic research, management decision making in organisations and potentially government policy making.

10.10.1 Academic Implications

The key academic implications for this research are in relation to the strategic management of technology literature. The thesis provides the first major step in mapping networks in relation to strategic management factors and thus providing the SMOT literature with its first true network perspective. This has implications for the way in which future research may examine the likes of strategic alliances and joint ventures which are key to the SMOT literature. The thesis has developed an integrated framework to analyse SMOT and network relationships. Mapping networks over time, a key aspect of the Conway (1997) template, has been added to the SIN framework. This provides a time-series analysis to the SMOT and innovation theory. This is an area of research around innovation and SMOT that has been largely ignored.

By addressing the failure of much of the SMOT and network literature to examine SMEs and mid-corporate firms I have undertaken research that concentrates on innovation in such organisations. The framework provides the means to undertake further research relating to networking in such organisations. The framework was utilised within the thesis to examine innovation projects that were in-house and involved limited long-term relationships with external actors. Generally in the cases presented only customers and suppliers were key and no strategic alliances or joint ventures were sought to develop new technology. Any alliance was purely on the basis of technological acquisition. Therefore, the framework could have implications for understanding strategic alliances in relation to the work being undertaken by Gulati (1998). Strategic alliances may involve varying networks, actors and relationships due to required strategies and resources.

A broader study of a larger number of organisations would be of interest to the subject area. The identification of very specific variables and a framework to organise and understand them through means that a quantitative orientated study could be achieved. We might therefore ask ourselves further 'how' and 'why' questions:

- do industries and sectors vary the relationship between strategy and networking?
- do resources affect the network orientation in relation to strategy?
- does firm size affect the relationship between strategy and structure?

Such a framework and understanding of the innovation process may also be of value to other theoretical areas. The framework provides a means of mapping and understanding the transfer of knowledge over time. It provides the means to view the orientation of such transfers and therefore provide management with an analysis that can inform their understanding of knowledge within the organisation and external to the organisation. The mapping can show how knowledge, expertise and artefacts are being used and accessed. In doing so allowing management to re-orientate actors and networks to make greater strategic use of knowledge. Therefore, the increasing literature relating to knowledge management may well benefit from such a framework.

10.10.2 Management Implications

The research undertaken has not attempted to make too many general statements about networking and the relationship with strategy. However, the answers to the propositions show that there are choices to be made by organisations wishing to enter into one of three corporate/technology strategies identified by Itami and Numagami (1992). The analysis has therefore focused on very specific product and process innovations with strong similarities between the organisations. It is difficult to generalise the findings in relation to mid-corporate manufacturing firms across the UK. However, the difficulty for strategic decision-makers and planners is to identify, understand and examine the relationship between strategy and networking within the organisational framework. The thesis has aimed to make steps to link strategy and network structure. The cases identify how traditional SMEs and mid-corporate firms become more innovative and overcome barriers to technological development and innovation. In terms of management, the initial results of this thesis would suggest that network choices relate to the strategy being followed. Therefore managers may potentially aid their strategy decisions through utilising particular network structures. Decisions may then be made on the basis of the relationship between strategy and networks in order to continue along the same path, make changes to networks, or even more dramatic, make changes to strategy. In a number of the cases discussed through the thesis it is questionable as to whether many of these projects would have occurred if it were not for particular individuals. Such individuals like Anthony Wascrop (DDL) and David Smith (OCL) were prepared to take risks to achieve particular outcomes. This entrepreneurial type figure within traditional small firms can be the difference between success and failure. Success and failure is also to some degree determined by the suitability of projects in relation to current and complementary competencies. The OCL example highlights the difficulties in developing radical new products through existing internal networks. Therefore, OCL management developed relationships with external sources to aid technological development. Whereas SUA begun to develop new products based on current competencies and incrementally altered them as new competencies were accessed through customers. What the cases show is that different networks meet different objectives. Having mapped these networks in relation to strategy and objectives, I have been able to identify the ways in which such networks may be formed and the dynamics involved. The stages identified provide a framework for management to form and evolve innovation networks based on the strategy being followed. The five network stages provide managers with options to meet particular strategies. For example a firm following a type 2 strategy should consider a network structure that develops both internal and external knowledge relationships. The formation and dynamics of networks and the actors involved are key issues for any project manager or management in general (Afuah, 1998: 35).

10.10.3 Policy Implications

Manufacturing output during the 1990s has been in decline (Jones and Tang, 1996b: 20). The thesis suggests that developing effective technology strategies can enable mid-corporate and SME firms to sustain output and employment levels. A view certainly shared by SUA. All the cases presented aimed to be more innovative in order to be more competitive. As suggested (Bannock and Partners, 1994/5) such firms make substantial contributions to the UK economy. This development of innovative capacity is presented at varying levels within the case – OCL aimed to be more radical than the rest whilst SUA developed new technologies and products based on in-house knowledge and skills. OCL's approach was most risky especially for resource limited SMEs and mid-corporate firms. I believe these cases illustrate how firms in a traditional sector can switch to a new technological trajectory or more simply develop internal technologies to enhance products and processes. The cases also highlight the dangers of moving away from the traditional business objectives (OCL case). The TMS project continued without fitting the corporate or technology strategy of the organisation and was supported well by senior management. However, the final product was out of step with the current market and OCL's strategy and therefore the TMS project was cancelled. The cases strongly support the view (Coombs et al, 1987; Dodgson and Rothwell, 1991; Iacoubucci, 1996) that the involvement of marketing and market knowledge and understanding throughout the technological development is crucial.

There are specific implications for a number of the companies involved in the thesis. WEL for instance developed a policy for acquiring technology through licensing and joint agreements. This is a relatively sound strategy however at the stage of the research the policy was applied throughout the organisation and the new product development committee. The company was reliant on these for future success. There was no internal new product development. DFM as with many of the companies (DDL included) was far too reliant on a small number of contracts with customers. This is especially risky when changing technological direction as relying on the support of one of two customers through this process may leave the organisation with serious problems if the change fails. The potentially most successful option of all the cases has been SUA. The company, although still at the time of the thesis, reliant on only two major customers saw the benefits of developing products based on existing or related markets that were complementary to current competencies. Such a policy makes best use of current competencies and resources whilst developing new products and learning from customers and suppliers.

The OCL and SUA cases spell out the need for the appropriate information to ensure such projects and developments benefit. OCL made critical errors in the early stages of the TMS by not obtaining market data and in the case of SUA key environmental changes effected its business potential to the point where it nearly went out of business. For this reason SUA specifically has utilised and developed external links to regulatory and government bodies in order to keep a breast of changes in the market place, in Europe and in terms of regulations. The pro-active rather than reactive stance taken by SUA can and often is difficult for SMEs and mid-corporate firms to engage in. Limited resources mean time and effort are concentrated on the day to day business.

The SIN framework has the potential to develop sustainable technology strategies and informs potential competitive situations. The framework was utilised at Warwick Business School as part of a study of the Internet and its impact on 500 SMEs at an organisational and competitive level. The aim was to develop regional competitiveness. Hence, the SIN framework may be utilised to identify sector differences; to identify differences in company size; whether locality within a region affects the virtual network or not; and whether internet technology assists companies to interact? Such research may impact on regional and national policy decision making with regards the use of the Internet and related technologies to stimulate regional growth and competitiveness.

10.11 CONCLUSION

The research objective was to integrate the strategic approach to the management of technology with the concept of innovation networks and identify and understand the dynamic innovation process from a network perspective. The SIN framework (Figure 10.1) forms the basis for this integration in terms of the mapping of network actors along with the framework of analysis developed. The identification and linking of variables within the two integrated frameworks. Chapter 9 utilises the framework in order to examine company strategy, to identify network approaches regarding product and process innovations and to develop the innovation process identifying five key dynamic stages. The main conclusions are:

- network types/structure utilised for innovations follow corporate/technology strategy
- there are five network stages identified in the dynamic innovation process: feasibility; formalisation; internalisation; functional; and operational
- the dynamic innovation process by definition alters with corporate/technology strategy

Undertaking the analysis over a long period of time allowed an extremely detailed set of data to be captured. The detail of the networks within each case provided a strong basis on which to examine the propositions and identify the dynamic innovation process from a strategic management and network perspective. Hence the SIN framework adds value to the SMOT literature and provides a tool for researchers, strategic decision makers and policy makers to rationally plan the development of networks for a particular strategy as well as strategies themselves.

REFERENCES

REFERENCES

Abernathy, W & Clark, K. B. (1985) Mapping the Winds of Creative Destruction, Journal: Research Policy, Vol: 14 (1), pp. 3-22

Abernathy, W. and Utterback, J.M. (1978) Patterns of Innovation In Technology, Journal: Technology Review, Vol: 80 (7), pp. 40-47

Achilladis, B., Robertson, A. and Jervis, P. (1971), Project SAPPHO: A Study of Success and Failure in Innovation, 2 Vols, University of Sussex: SPRU.

Ackroyd, S. (1995) On the Structure & Dynamics of Some Small UK-Based Information Technology Firms, Journal of Management Studies, Vol: 32 (2), pp. 141-63

Afuah, A (1998) Innovation Management - Strategies, Implementation, and Profits, Published: Oxford University Press, Inc.

Allen T. J. (1971) Communication Networks in R&D Laboratories, Journal: R&D Management, Vol: 1 (1), pp. 14-21

Allen, T. J. (1977) Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within the R&D Organisation, Published: MIT Press, Boston

Alter, C. and Hage J. (1993) Organisations Working Together, Published: Newbury Park, CA, Sage.

Amit R. and Schoemaker, P J H (1993) Strategic Assets and Organisational Rent, Journal: Strategic Management Journal, Vol: 14 (1), pp. 33-46

Ancona, D G. and Caldwell, D. F. (1997) Making Teamwork Work: Boundary Management in Product Development Teams, in Tushman, M L and Anderson, P (eds.), Managing Strategic Innovation and Change, Oxford University Press, pp. 433-442

Anderson, P. and Tushman, M. L. (1997) Managing Through Cycles of Technological Change in Tushman, M. L. and Anderson, P. (eds) (1997) Managing Strategic Innovation and Change - A Collection of Readings, Published: Oxford University Press, pp 45-52

Ansoff, H. I (1965) Corporate Strategy, Published: Penguin, Marmondworth

Asch D. and Bowman, C. (1989) Readings In Strategic Management, Published: MacMillan in Association with Open University Press

Auster, E (1990) The Interorganisational Environment: Network Theory, Tools and Applications in Williams, F. and Gibson, D. (eds), Technology Transfer: A Communication Perspective, Published: Sage, pp. 63-89

Autio E. (1995) The King and His Clothes: Ten General Misconceptions of New, Technology-Based Firms, mimeo, Institute of Industrial Management, Published: Helsinki University of Technology, Finland

Autio, E. (1997) New, Technology-Based Firms in Innovation Networks Symplectic and Generative Impacts, Journal: Research Policy, Vol: 26 (3), pp. 263-281

Baden-Fuller, C. and Pitt, M. (eds) (1996) Strategic Innovation - An International Casebook on Strategic Management, Published: Routledge

Bahrami, H. and Evans, S. (1987) Stratocracy in High-technology Firms, Journal: California Management Review, Fall, Vol: 30 (1), pp. 51-66

Bannock, Graham and Partners (1994/5) A Quarterly Review of Enterprises in the £1 Million to £130 Million Turnover Sizeband, Published: Mid-Corporate Directions, Vol: 1 (2)

Barber, B. (1952) Science and the Social Order, Published: Collier Books, New York

Barley, S. (1986) Technology as an Occasion for Structuring: Evidence from Observation of CT Scanners and the Social Order of Radiology Departments, Journal: Administrative Science Quarterly, Vol: 31 (1), pp. 78-108

Barnes, J. A. (1954) Class and Committees in a Norwegian Island Parish, Journal: Human Relations, Vol: VII, pp. 39-58

Barney, J. B. (1986) Strategic Factor Markets: Expectations, Luck and Business Strategy, Journal: Management Science, Vol: 32 (10), pp. 1231-1241

Bartunek, J.M. (1976) Changing Interpretive Schemes and Organisational Restructuring: The Examples of a Religious Order, Journal: Administrative Science Quarterly, Vol: 29 (1), pp. 355-372

Berry, M. M. J. (1996) Technical Entrepreneurship, Strategic Awareness and Corporate Transformation in Small High-Tech Firms, Journal: Technovation, Vol: 16 (9), pp. 487-498

Berry, M. M. J. and Taggart, J. H. (1994) Managing Technology and Innovation: A Review, Journal: R&D Management, Vol: 24 (4), pp. 341-353

Berry, M.M.J. and Taggart, J.H. (1998) Combining Technology and Corporate Strategy in Small High Tech Firms, Journal: Research Policy, Vol: 26 (7/8), pp. 883-895

Bertin, J. (1983) Semiology of Graphics: Diagrams, Networks, Maps. Translated by W. Berg. Wisconsin: University of Wisconsin Press.

Betz, F. (1987) Managing Technology, Published: New York, Englewood Cliffs, New Jersey.

Bhalla, S. K. (1987) The Effective Management of Technology, Published: Reading, Battelle Press

Bianchi, P. and Bellini, N. (1991) Public Policies for Local Networks of Innovators, Journal: Research Policy, Vol: 20 (5), pp. 487-497

Birley, S. (1989) Corporate Strategy and the Small Firm, in Asch D. and Bowman, C. (eds.), Readings In Strategic Management, Published: MacMillan in Association with Open University Press, pp. 78-81

Boje, D. M. and Whetten, D. A. (1981) Effects of Organizational Strategies and Contextual Constraints on Centrality and Attribution of Influence on Inter-organizational Networks, Journal: Administrative Science Quarterly, Vol: 26 (4), pp. 378-395.

Bowman, C. (1998) Strategy in Practice, Published: Prentice Hall Europe, Simon and Schuster International Group.

Bracker, J. (1980) The Historical Development of the Strategic Management Concept, Journal: Academy of Management Review, Vol: 5 (2), pp. 219-224

Braun, E. (1998) Technology In Context - Technology Assessment for Managers, The Management of Technology and Innovation Series, Published: Routledge, London and New York

Brewster-Stearns, L. and Mizruchi, M. S. (1986) Broken-tie Reconstitution and the Function of the Inter-organizational Interlocks: A Re-examination, Journal: Administrative Science Quarterly, Vol: 31 (4), pp. 522-538

Bryman, A. (1989) Research Methods and Organisation Studies, Contemporary Social Research, Published: London Unwin Hyman Ltd.

Burgelman, R. A. (1985) Managing The New Venture Division: Research Findings and Implications for Strategic Management, Journal: Strategic Management Journal, Jan/Mar, Vol: 6 (1), pp. 39-55

Burns, P. and Dewhurst, J. (1989) Small Business and Entrepreneurship, Published: Macmillan

Burns, T. and Stalker, G. (1961) The Management of Innovation, Published: Tavistock, London

Burt, R. S. (1992) Structural Holes: The Social Structure of Competition, Published: Cambridge, MA, Harvard University Press.

Callon, M. (1992) The Dynamic of Techno-Economic Networks in Coombs et al (eds) Technological Change and Company Strategies: Economic and Sociological Perspectives, Published: Academic Press, London

Casson, M. and Cox, H. (1997) An Economic Model of Inter-firm Networks in The Formation of Interorganizational Networks, M. Ebers (ed.), Published: Oxford University Press, pp. 174-196

CEST (1990) Attitudes to the Exploitation of Science and Technology, Manchester Centre for the Exploitation of Science and Technology.

Chaffee, E. E. (1985) Three Models of Strategy, Journal: Academy of Management Review, Vol: 10 (1), pp. 89-98

Chandler, A. D. (1962) Strategy and Structure: Chapters in the History of The American Industrial Enterprise, MIT Press, Cambridge

Charles, D. and Howells, J. (1992) Technology Transfer in Europe: Public and Private Networks. London: Belhaven

Chase, R. B., Aquilano, N. J. and Jacobs, F. R. (1998) Production and Operations Management: Manufacturing and Services, Published: Boston, Irwin McGraw-Hill

Chesbrough, H. W. and Teece, D. J. (1996) When is Virtual Virtuous? Organising for Innovation, Journal: Harvard Business Review, Jan/Feb, Vol: 74 (1), pp 65-79

Ciborra, C. (1990) Tecnologie di coordinamento, Published: Milan: Angeli.

Clark, P. and Staunton, N. (1993) Innovation in Technology and Organisation, Published: Routledge, London

Contractor, P. J. and Lorange, P. (1988) Co-operative Strategies in International Business, Published: Lexington Books

Conway, S. (1997) Focal Innovation Action-Sets: A Methodological Approach for Mapping Innovation Networks, Research Paper Series Aston University, Aston Business School Research Institute, No. RP9702

Conway, C. and Steward, F. (1998) Mapping Innovation Networks, Journal: International Journal of Innovation Management, Vol: 2 (2), pp. 223-254

Cooke, P. (1996) The New Wave of Regional Innovation Networks: Analysis, Characteristics and Strategy, Journal: Small Business Economics, Vol: 8 (2) , pp. 159-171

Coombs, R. (1994) Technology and Business Strategy in Dodgson M. and Rothwell R. (eds.), The Handbook of Industrial Innovation, Published: Edward Elgar Publishing, pp. 384 - 392

Coombs, R.; Richards, A.; Saviotti, P.; and Walsh, V. (1987) Economics and Technological Change, Published: Macmillan Education Ltd.

Coombs, R., Richards, A., Saviotti, P. and Walsh, V. (1996) Technological Collaboration - The Dynamics of Co-operation in Industrial Innovation, Published: Edward Elgar Publishing Limited

Crane, D. (1972) Invisible Colleges: Diffusion of Knowledge in Scientific Communities, Published: University of Chicago Press, Chicago

Curran, J. J. and Blackburn , R. (1994) Small Firms and Local Economic Networks, The Death of the Local Economy, Published: Paul Chapman Publishing, London

Daft, R.L. (1992) Organisational Theory and Design (Fourth Edition), Published: West Publishing Company

Davis, G. F. (1991) Agents Without Principals? The Spread of the Poison Pill through the Intercorporate Network, Journal: Administrative Science Quarterly, Vol: 36 (4), pp. 583-613.

DeBresson, C. and Amesse, F. (1991) Networks of Innovators: A Review and Introduction to the Issues, Journal: Research Policy, Vol: 20 (5), pp. 363-379

De Meyer, A. (1985) The Flow of Technical Information in an R&D Department, Journal: Research Policy, Vol: 14 (6), pp. 315-328

De Meyer, A. (1991) Tech Talk: How Managers Are Stimulating Global R&D Communication, Journal: Sloan Management Review, Spring 1991, Vol: 32 (3), pp. 48-58

Dodgson, M. (1989) Technology Strategy and the Firm, Management and Public Policy, editor Mark Dodgson, Published: Longman

Dodgson, M. (1991) Managing Corporate Technology Strategy, Journal: International Journal of Technology Management, Special Publication on the Role of Technology in Corporate Policy, pp. 95-102

Dodgson, M. (1993) Technological Collaboration in Industry, Strategy, Policy and Internationalization in Innovation, Published: London, New York, Routledge

Dodgson, M. and Rothwell, R. (1991) Technology Strategies in Small Firms, Journal: Journal of General Management, Vol: 17 (1), pp. 45-55

Doz, Y and Hamel, G (1997) The Use of Alliances in Implementing Technology Strategies, in Tushman, M L and Anderson, P (eds.), Managing Strategic Innovation and Change, Oxford University Press, pp. 556-580

Drejer A. (1996) Integration of Business Strategy and Competence Development, PhD Thesis, Aalborg University, Department of Production, October 1996

DTI Web-Site, Small Business Papers - http://www.dti.gov

Dussauge, P., Hart, S. and Ramanantsoa, B. (1987) Strategic Technology Management - Integrating Product Technology into Global Business Strategies for the 1990s, Published: John Wiley and Sons Ltd.

Dyer, J. H. (1996) Specialised Supplier Networks as a Source of Competitive Advantage: Evidence from the Auto Industry, Journal: Strategic Management Journal, Vol: 17 (4), pp. 271-291.

Easton, G. and Araujo, L. (1997) Interfirm Responses to Heterogeneity of Demand Over Time, in The Formation of Inter-organizational Networks. M. Ebers (ed.), Published: Oxford University Press, pp. 66-94.

Ebers, M. (1997) Explaining Inter-organizational Network Formation, in The Formation of Inter-organizational Networks. M. Ebers (ed.), Published: Oxford University Press, pp. 3-40

Ebers, M. (1993) IT Networks as Organizational Forms, Paper presented at the 11th E.G.O.S. Colloquium, The production and diffusion of managerial knowledge, Published: Paris

Ebers, M. and Jarillo, J. C. (1998) The construction, forms and consequences of industry networks. Journal: International Studies of Management and Organization, Vol: 27 (4), pp. 3-21.

Fombrun, C. J. (1982) Strategies for Network Research in Organizations, Journal: Academy of Management Review, Vol: 7 (2), pp. 280-291

Ford, D. (1988) Develop Your Technology Strategy, Journal: Long Range Planning, Vol: 21 (5), pp. 85-95

Ford, D. and Thomas, R. (1997) Technology Strategy in Networks, Journal: Int. Journal of Technology Management, Vol: 14 (6/7/8), pp. 596-612

Forrest, J.E. and Martin, M.J.C. (1992) Strategic Alliances Between Large and Small Research Intensive Organisations: Experiences in the Biotechnology Industry, Journal: R&D Management, Vol: 22 (1), pp. 41-54

Foss, N. J. (1997) Resources, Firms and Strategies - A Reader in the Resource-Based Perspective, Edited by Foss, Published: Oxford University Press

Foster, R. (1986) Innovation: The Attacker's Advantage, Published: Summit Books, New York Press

Fourcade, C. (1993) Networking Strategies for Small Firms Coping with Globalisation, in The Impact of Globalisation on Europe's Firms and Industries, Marc Humbert (eds), Published: Pinter Publishers, Chapter 21, pp. 211-217

Frankenberg, R. J. (1966) Communities in Britain: Social Life in Town and Country, Published by Harmondsworth, Penguin Books

Fredrickson, J. W. (1983) Strategic Process: Questions and Recommendations, Journal: Academy of Management Review, Vol: 8 (4), pp. 565-75

Freeman, C. (1991) Networks of Innovators: A Synthesis of Research Issues, Journal: Research Policy, Vol: 20 (5), pp. 499-514

Freeman C. and Perez, C. (1988) Structural Crises of Adjustment, Business Cycles and Investment Behaviour, in Dosi, G. et al. (eds) Technical Change and Economic Theory, Published: Pinter, London, pp. 38-65

Gadde, L. E. and Mattsson, L. G. (1987) Stability and Change in Network Relationship, Published: Elsevier Science Publishers - Amsterdam.

Galaskiewicz, J (1996) The 'New Network Analysis' and Its Implication To Organisational Theory and Behaviour, in Iacoubucci, D. (eds) Networks In Marketing, Published: Sage, London, pp. 19-31

Galaskiewicz, J. and Burt, R. (1991) Inter-organization Contagion in Corporate Philanthropy, Journal: Administrative Science Quarterly, Vol: 36 (1), pp. 88-105.

Galaskiewicz, J. and Wasserman, S. (1989) Mimetic Processes within an Organizational Field: An Empirical Test, Journal: Administrative Science Quarterly, Vol: 34 (3), pp. 454-479.

Galbraith, J. (1974) Designing Complex Organisations, Published: Reading, MA - Addison-Wesley

Gaynor, G. H. (1991) Achieving The Competitive Edge Through Integrated Technology Management, Published: New York, McGraw-Hill.

Gerlach, M. L. (1992)a Alliance Capitalism, Published: Berkeley, CA, University of California Press.

Gerlach, M. L. (1992)b The Japanese Corporate Network: A Block Model Analysis, Journal: Administrative Science Quarterly, Vol: 37 (1), pp. 105-139.

Gibbons, M. and Johnston, R. (1972) The Roles of Science in Technological Innovation, Journal: Research Policy, Vol: 3 (2), pp. 220-242

Giddens, A. (1984) The Constitution of Society, Published: Cambridge, Polity

Gille, B. (1978) Histoire des Techniques, Published: Paris - Gallimard

Goodman, Richard A and Lawless, Michael W, (1994) Technology and Strategy: Conceptual Models and Diagnostics, Published: Oxford University Press

Goold, M. and Campbell, A (1987) Strategies and Styles, Published: Blackwell, Oxford

Gottschalk, L., Kluckholm C. and Angell, R. (1945) The Use of Personal Documents in History, Anthropology and Sociology, Published: New York: Social Science Research Council

Grabher, G. (ed.) (1993) The embedded firm. Published: London: Routledge.

Grandori, A. and Soda, G. (1995) Inter-firm Networks: Antecedents, Mechanisms, and Forms, Journal: Organization Studies, Vol: 16 (2), pp 183-214.

Granovetter, M. (1973) The Strength of Weak Ties, Journal: American Journal of Sociology, Vol: 78(3), pp. 1360-1380

Granovetter, M. (1985) Economic Action and Social Structure: The Problem of Embeddedness, Journal: American Journal of Sociology, Vol: 91(3), pp. 481-510

Granovetter, M. and Swedberg, R. (1992) The Sociology of Economic Life, edited by Mark Granovetter and Richard Swedberg, Published: Boulder, Westview Press

Gulati, R. (1995) Social Structure and Alliance Formation Patterns, Journal: Administrative Science Quarterly, Vol: 40 (4), pp. 619-652

Gulati, R. (1998) Alliance and Networks, Journal: Strategic Management Journal, Vol: 19 (4), pp. 293-317

Gulati, R. (1999) Network Location and Learning: The Influence of Network Resources and Firm Capabilities on Alliance Formation, Journal: Strategic Management Journal, Vol: 20 (5), pp. 397-420

Hagedoorn, J. (1993) Strategic Technology Alliances and Modes of Cooperation in High-Technology Industries, in Grabher, G. (eds), The embedded firm. Published: London: Routledge pp. 116-138

Hagedoorn, J. and Schakenraad, J. (1990) Inter-Firm Partnerships and Cooperative Strategies in Core Technologies, in Freeman, C. and Soete, L, (eds) New Explorations in the Economics of Technical Change, Published: London, Pinter, pp. 1-37

Hagedoorn, J. and Schakenraad, J. (1992) Leading Companies and Networks of Strategic Alliances in Information Technologies, Journal: Research Policy, Vol: 21 (2), pp. 163-190

Hakansson, H. (1987) Industrial Technological Development: A Network Approach, Published: London, Croom Helm

Hakansson, H. and Johanson, J. (1990) Formal and Informal Co-operation Strategies, in International Industrial Networks in Understanding Business Markets, Ford, D. (eds), Published: Academic Press, London, pp. 459-467

Hakansson, H. and Snehota, I. (1995) Developing Relationships in Business Networks, Published: Routledge

Harrigan, K (1985) Strategies for Joint Ventures, Published: Lexington Books

Harrod, R. F. (1948) An Essay In Dynamic Theory, Journal: Economic Journal, Vol: 49 (1), pp. 14-33

Haunschild, P. (1993) Inter-organizational Invitation: The Impact of Interlocks on Corporate Acquisition Activity, Journal: Administrative Science Quarterly, Vol: 38 (4), pp. 564-592.

Hayes, R, Wheelwright, S, and Clark, K. (1988) Dynamic Manufacturing, Published: New York, Free Press.

Heide, J. B. (1994) Interorganizational Governance in Marketing Channels, Journal: Journal of Marketing, Vol: 58 (1), pp. 71-85.

Henderson, R. and Clark, K. (1990) Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms, Journal: Administrative Science Quarterly, Vol: 35 (1), pp. 9-30

Herrigel, G. B. (1995) Industrial Constructions: The Sources of German Industrial Power, Published: New York, Cambridge University Press.

Hill, C. W. L. and Jones, G. R. (1995) Strategic Management: An Integrated Approach, Published: Boston MA, Houghton Mifflin

Hobday, M. (1994) Innovation in Semiconductor Technology: The Limits of the Silicon Valley Network Model, in Dodgson M. and Rothwell R. (eds.), The Handbook of Industrial Innovation, Published: Edward Edgar Publishing Ltd, pp. 154-68

Hoffman, K., Parejo, M., Bessant, J. and Perren, L. (1998) Small Firms, R&D, Technology and Innovation in the UK: A Literature Review, Journal: Technovation, Vol: 18 (1), pp. 39-55

Humbert M. (1993) The Impact of Globalisation on Europe's Firms and Industries, Edited by Marc Humbert, Published: Pinter Publishers Ltd.

Itami, H. and Numagami, T. (1992) Dynamic Interaction Between Strategy and Technology, Journal: Strategic Management Journal, Vol: 13 (4), pp. 119-135

Jain, R. K. and Triandis, H. C. (1990) Management of R&D Organisations, Published: New York, John Wiley & Sons

Jain, R. K. and Triandis, H. C. (1997) Management of R&D Organisations, Second Edition, Published: New York, John Wiley & Sons

Jarillo, J. C. (1993) Strategic Networks: Creating the Borderless Organization, Published: Oxford, Butterworth-Heinemann.

Johnson, G. (1989) Strategic Change and the Management Process, Published: Oxford, Blackwell

Johnson, G. & Scholes, K (1999) Exploring Corporate Strategy - Fifth Edition, Published: Prentice Hall - Europe

Jones, O. and Beckinsale, M. J. J. (1994) Alliances Between SMEs and HEIs: Technology Management in Otter Controls, Report for the DTI Innovation Unit

Jones, O., Conway, S. and Steward, F. (1999), Social Interaction and Organisational Change: Aston Perspectives on Innovation Networks, Research Paper Series - Aston University, Aston Business Research Institute, RP9934

Jones, O., Edwards, T. and Beckinsale, M. (2000) Technology Management in a Mature Firm: Structuration Theory and the Innovation Process, Journal: Technology Analysis and Strategic Management, Vol; 12 (2)

Jones, O. and Smith, D. (1997) Strategic Technology Management in a Mid-Corporate Firm: The Case of Peak Controls, Research Paper Series - Aston University, Aston Business School Research Institute, RP9511

Jones, O. and Tang, N. (1996a) What is Technology Strategy & Does it Matter?, Research Paper Series - Aston University, Aston Business School Research Institute, RP9613

Jones, O and Tang, N. (1996b) Mature Firms in the UK Mid-Corporate Sector: Linking Corporate, Technology & Manufacturing Strategies, Paper presented at Manufacturing Matters: Organisational & Employee Relations in Modern Manufacturing, Cardiff, September 1996

Kamann, D. and Strijker, J (1991) In Search of the Spider in the Web, Paper initially presented at the 28th annual meeting of Western Regional Science meeting, San Diego (California), Feb 1989, complete paper - Journal: European Review of Agriculture Economics (1991).

Kanter, R. M. (1972) Commitment and Community, Published: Cambridge University Press, Massachusetts

Karlsson, C. (1994) From Knowledge and Technology Networks to Network Technology, in Johansson, C., Karlsson, C. and Westin, L. (eds) Patterns of a Network Economy, Published: Berlin, Springer-Verlag, pp. 152-185

Katz, F. E. (1966) Social Participation and Social Structure, Journal: Social Forces xiv, pp. 199-210

Kaufman, A., Wood, C. H. and Theyel, G. (2000) Collaboration and Technology Linkages: A Strategic Supplier Typology, Journal: Strategic Management Journal, Vol: 21, pp. 649-663

Kidder, T (1981) The Soul of a New Machine, Published: New York, Avon Books

Kogut, B., Shan, W. and Walker G. (1993) Knowledge in the Network and the Network as Knowledge: The Structuring of New Industries, in Grabher, G. (ed) The Embedded Firm: On the Socio-Economics of Industrial Networks, Published: London: Routledge, pp. 67-94

Krackhardt, D. (1990) Assessing the Political Landscape: Structure, Cognition and Power in Networks, Journal: Administrative Science Quarterly, Vol: 35 (2), pp. 342-369

Kumar, R (1996) Research Methodology: A Step-By-Step Guide For Beginners, Published: Addison Wesley Longman Australia Pty Limited

Kuznets, S. (1930) Secular Movements in Production and Prices, Published: Boston, Houghton Mifflin

Lane, C. and Bachmann, R. (1996) The Social Constitution of Trust: Supplier Relations in Britain and Germany. Journal: Organization Studies, Vol: 17 (3), pp. 365-393

Langrish, J., Gibbons, M., Evans, W. and Jevons, F. (1972) Wealth From Knowledge: A Study of Innovation in Industry, Published: London Macmillan.

Larson, A. (1992) Network Dyads in Entrepreneurial Settings: A Study of the Governance of Exchange Relationships, Journal: Administrative Science Quarterly, Vol: 37 (1), pp. 76-104.

Latour, B. (1999) On Recalling ANT, in Law, J. and Hassard, J. (eds) Actor Network Theory and After, Published: Blackwell, Oxford

Laumann, E. (1983) The Boundary Specification Problem in Network Analysis, in Burt, R. & Minor, M. S. (eds.), Applied Network Analysis: A Methodological Introduction, Published: Beverley Hills, pp. 18-34

Law, J. and Hassard, J. (1999) (eds) Actor Network Theory and After, Published: Blackwell, Oxford

Lawrence, P. R. and Lorsch, J. W. (1967) Organisation and Environment, Division of Research, Graduate School of Business, Harvard University.

Lee, G.L. (1994) The Relevance of Strategy Theories to the Smaller Firm, Aston Business School Research Paper, Aston Business School Research Institute, RP9409

Lewis, J. D. (1990) Partnerships for Profit: Structuring and Managing Strategic Alliances, Published: New York - Free Press

Likert, R. and Likert, J. G. (1976) New Ways of Managing Conflict, Published: McGraw-Hill, New York

Linstone, H. A. and Turoff, M (eds) (1975) The Delphi Method: Techniques and Applications, Published: Addison-Wesley Publishing Company

Little, A. D (1981) The Strategic Management of Technology, Published: A. D. Little Consulting Group

Lorsch, J. W. and Lawrence, P. R. (1970) Studies in Organisation Design, edited by Lorsch, J. W. & Lawrence, P. R. (eds), Published: Homewood (Ill) Irwin

Loveridge, R. and Pitt, M. (1990) The Strategic Management of Technological Innovation, Published: New York, Wiley

Lowe P (1995), The Management of Technology: Perception and Opportunities, Published: Chapman & Hall

Marquis, D. and Allen, T. (1966) Communication Patterns in Applied Technology, Journal: American Psychologist, Vol: 21, pp. 1052-1060

Mayer, P. (1961) Tribesmen or Townsmen: Conservatism and the Process of Urbanisation in South African City, Cape Town, Published by Oxford University Press

Merton, R. (1957) Social Theory and Social Structure, Published: Glencoe, Illinois: Free Press

Meyer, M. H. and Roberts, E. B. (1988) Focusing Product Technology for Corporate Growth, Journal: Sloan Management Review, Summer, Vol: 29 (4), pp. 7-16

Miles, R. E. & Snow, C. C, (1978) Organisation Strategy, Structure, and Process, - International Student Edition, Published: McGraw-Hill Kogakusha Ltd.

Miles, R.E. & Snow, C.C. (1986) Organisations: New Concepts for New Forms, Journal: California Management Review, Vol: 28 (3), Spring, pp. 62-73

Mintzberg, H. (1973) Strategy Making in Three Modes, Journal: California Management Review, Winter, Vol: 16 (2), pp. 44-53

Mintzberg, H. (1979) The Structuring of Organisations, Published: Englewood Cliffs, NJ - Prentice Hall

Mitchell, J. (1969) Introduction and The Concept and Use of Social Networks, in Mitchell, J. (eds.), Social Networks in Urban Situations, Published: Manchester University Press, pp. 1-50

Mizruchi, M. S. (1994) Social Network Analysis: Recent Achievements and Current Controversies, Journal: Acta Sociologica, Vol: 37 (4), pp. 329-343.

Mizruchi, M. S. and Galaskiewicz, J. (1993) Networks of Interorganizational Relations, Journal: Sociological Methods and Research, Vol: 22, pp. 46-70.

Mody, A. (1990) Learning Through Alliances, World Bank, mimeo, Washington

Monck, C. S. P., Porter, R. B., Quintas, P. R., Storey, D. J. and Wynarczyk, P. (1988) Science Parks and The Growth of High Technology Firms, Published by Croom Helm, Beckenham, Kent.

Monger, R. F. (1988) Mastering Technology: A Management Framework For Getting Results, Published: New York, The Free Press

Morin, J. (1985) L'Excellence Technologique, Published: Paris, Jean Picollec-Publi-Union.

Nachmias, D and Nachmias, C. (1992) Research Methods in the Social Sciences, Published: New York St. Martin

Nelson, R. and Winter, S. (1974) Neo-classical and Evolutionary Theories of Growth: Critique and Prospectus, Journal: Economic Journal, Vol: 84, pp. 886-905

Nishiguchi, T. (1994) Strategic Industrial Sourcing: The Japanese Advantage, Published: Oxford University Press, U.K.

Nohria, N. and Eccles, R.G. (1992) Networks and Organizations, Structure, Form, and Action, Nohria N. and Eccles R. G. (eds.), Published: Boston, Mass., Harvard Business School Press

Nonaka, I. (1990) Redundant, Overlapping Organisation: A Japanese Approach to Managing The Innovation Process, Journal: California Management Review. Vol: 32 (3), pp. 27-38

Nonaka, I. (1997) Redundant, Overlapping Organisation: A Japanese Approach to Managing The Innovation Process, in Tushman, M L & Anderson, P (eds.), Managing Strategic Innovation and Change, Published: Oxford University Press, pp. 443-451

Nonaka, I., Takeuchi, H. and Umenoto, K. (1996) A Theory of Organisational Knowledge Creation, Journal: International Journal of Technology Management, Special Issues on Unlearning and Learning for Technological Innovation, Vol: 11 (7/8), pp. 833-845

Oliver, C. (1997) Sustainable Competitive Advantage: Combining Institutional And Resource Based Views, Journal: Strategic Management Journal, Vol: 18 (9) pp. 697-713

Palmer, D. (1983) Broken Ties: Interlocking Directorates and Intercorporate Co-ordination, Journal: Administrative Science Quarterly, Vol: 28 (1), pp. 40-55.

Pappas, C. (1984) Strategic Management of Technology, Journal: Journal of Product Innovation Management, Vol: 1 (1), pp. 30-35

Pavitt, K. (1986) Technology, Innovation and Strategic Management, in McGee, J. Thomas, H. (eds.), Strategic Management Research: A European Perspective, Published: Wiley, West Sussex, pp. 171-192

Pearson, A. W. (1992) Managing Innovation: An Uncertainty Reduction Process, in Henry, J. and Walker, D. (eds). Managing Innovation, Published: Sage Publications Limited. pp. 18-27

Peters, T. J. and Waterman, R. H. (1982) In Search of Excellence, Published: New York, Harper and Row

Pfeffer, J. (1981) Management as Symbolic Action: The Creation and Maintenance of Organisational Paradigms, in Cummings L. L. and Staw, B. M. (eds), Research in Organisational Behaviour, Vol 3, Published: Greenwich Press, pp. 1-15

Pfeffer, J. and Salancik, G. R. (1978) The External Control of Organizations: A Resource Dependence Perspective. New York: Harper and Row.

Pinch, S. (1998) Innovation, Networks and Learning Regions? Journal: Regional Studies, Vol: 32 (1), Feb, pp. 98-99

Pisano, G. P. (1989) Using Equity Participation to Support Exchange: Evidence From the Biotechnology Industry, Journal: Journal of Law, Economics, and Organization, Vol: 5, pp. 109-126.

Porter, M. E. (1983) The Technological Dimension of Competitive Strategy, in Rosenbloom, R. S. (eds), Research on Technological Innovation, Management of Policy, Vol: 1, Published: JAI Press, Greenwich, CT, pp. 1-33

Porter, M. E. (1985), Competitive Advantage, Published: The Free Press

Porter, M. E. (1991) From Competitive Advantage to Corporate Strategy, in Montgomery C.A and Porter M.E. (eds), Strategy - Seeking and Securing Competitive Advantage, Published: Harvard Business Review, pp. 225-256

Porter, M. E. and Fuller M. B. (1986) Coalitions and Global Strategy, in Competition in Global Industries, M.E. Porter (ed.), Published: Boston, MA, pp. 315-344.

Powell, W. W. (1990) Neither Market nor Hierarchy: Network Forms of Organization. Journal: Research in Organizational Behaviour, Vol: 12, pp. 295-336.

Powell, W. W. and Smith-Doerr, L. (1994) Networks and Economic Life, in The Handbook of Economic Sociology. N.J. Smelser and R. Swedberg (eds.), Published: Princeton, NJ: Princeton University Press, pp. 368-402

Prahalad, C.K. (1993) The Role of Core Competencies in the Corporation, Journal: Research Technology Management, Vol: 36 (6), pp. 40-47

Prahalad, C.K. (1997) The Role of Core Competencies in the Corporation, Research Technology Management, in Tushman, M L & Anderson, P (eds.), Managing Strategic Innovation and Change, Oxford University Press, pp. 172-182

Prahalad, C.K. and Hamel, G. (1990) The Core Competence of the Corporation, Journal: Harvard Business Review, Jan-Jun, Vol: 68 (3), pp. 79-91

Quinn, J. B. (1978) Strategic Change: Logical Incrementalism, Journal: Sloan Management Review, Fall, Vol: 20 (1), pp. 7-21

Quinn, J. B. (1980) Strategies for Change, Published: Homewood, IL: Irwin

Quinn, J. B. (1989) Managing Strategic Change, in Asch, D. and Bowman, C. (eds.), Readings in Strategic Management, Published: Open University, Macmillan. pp. 20-36

Quinn, J. B., Philip, A. and Finkelstein, S. (1997) Managing Intellect, in Tushman, M L & Anderson, P (eds.), Managing Strategic Innovation and Change, Published: Oxford University Press, pp. 506-523

Ring, P.S. and Van de Ven A. H. (1992) Structuring Cooperative Relationships Between Organizations, Journal: Strategic Management Journal, Vol: 13 (7), pp. 483-498.

Roberts, E. B. (1983) Strategic Management of Technology In Global Technological Change, Synposium Proceedings, MIT Industrial Liaison Program, Published: Cambridge, MA, June.

Roberts, E. B. (1987) Generating Technological Innovation, Published by Oxford University Press, New York

Roberts, E. B and Berry, C. A. (1985) Entering New Businesses: Selecting Strategies for Success, Journal: Sloan Management Review, Spring 1985, Vol: 26 (3), pp. 3-17

Roberts, E.B. and Fusfeld, A.R. (1981) Staffing the Innovative Technology Based Organisation, Journal: Sloan Management Review, Spring, Vol: 22 (3), pp. 19-34

Rogers, E.M. (1987) Progress, Problems and Prospects for Network Research: Investigating Relationships in the Age of Electronic Communications, Paper presented at the VII Sunbelt Social Networks Conference, Florida, Feb. 12-15th

Rogers, E and Kincaid, D (1981) Communication Networks, New York: Free Press

Rosenthal, R. (1966) Experimenter Effects in Behavioural Research, Published: New York Appleton-Century-Crofts

Rothwell, R. (1982), Innovation and the Small and Medium Sized Firm, their Role in Employment and in Economic Change, Roy Rothwell (ed.), Published: London, Frances Pinter

Rothwell, R. (1989) Small Firms, Innovation and Industrial Change, Journal: Small Business Economics, Vol: 1 (1), pp. 51-64

Rothwell, R. (1994) Industrial Innovation: Success, Strategy, Trends, in Dodgson M. & Rothwell R. (eds.), The Handbook of Industrial Innovation, Published: Edward Elgar Publishing, pp. 33 - 53

Rothwell, R. and Dodgson, M. (1994) Innovation and Size of Firm, in Dodgson M. and Rothwell R. (eds.), The Handbook of Industrial Innovation, Published: Edward Edgar Publishing Ltd, pp. 310-324

Rothwell, R and Zegveld, W. (1985) Re-industrialisation and Technology, Published by Longman, London

Roy, W. G. and Bonacich, P. (1988) Interlocking Directorates and Communities of Interest Among American Railroad Companies, 1905, Journal: American Sociological Review, Vol: 53 (3), pp. 368-379.

Sako, M. (1994) Supplier Relationships and Innovation, in Dodgson M. and Rothwell R. (eds.), The Handbook of Industrial Innovation, Published: Edward Elgar Publishing, pp. 268 - 274

Salancik, G. R. (1995) WANTED: A Good Network Theory of Organization, Journal: Administrative Science Quarterly, Vol: 40 (2), pp. 345-349.

Sathe, V. (1985) Culture and Related Corporate Realities, Published: Homewood, IL, Irwin

Saxenian, A. (1991) The Origins and Dynamics of Production Networks in Silicon Valley, Journal: Research Policy, Vol: 20 (5), pp. 423-437

Scarbrough, H. (1999) Knowledge as Work: Conflicts in the Management of Knowledge Workers, Journal: Technology Analysis and Strategic Management, Vol: 11 (1), pp. 5-16

Schein, E. H. (1985) Organisational Culture and Leadership, Published: San Francisco: Jossey Bass

Scott, J. Social Network Analysis: A Handbook, Published: Sage, London

Scott, A. J. (1991) The Aerospace - Electronics Industrial Complex of Southern California: The Formative Years, 1940-1960. Journal: Research Policy, Vol: 20 (5), pp. 439-452

Schmookler, J. (1966) Invention and Economic Growth, Published: Harvard University Press

Schumpeter, J. A. (1934) The Theory of Economic Development, Published: Harvard University Press, Cambridge

Schumpeter, J. A. (1943) Capitalism, Socialism and Democracy, Published: New York; Harper and Row

Shaw, B. (1994) User/Supplier Links and Innovation, in Dodgson M. and Rothwell R. (eds.), The Handbook of Industrial Innovation, Published: Edward Elgar Publishing, pp. 275 - 284

Sheldon, A. (1980) Organisational Paradigms: A Theory of Organisational Change, Journal: Organisational Dynamics, Vol: 8 (3), pp. 61-71

Shrum, W. (1990) Status Incongruence Among Boundary Spanners: Structure, Exchange and Conflict, Journal: American Sociological Review, Vol: 55 (4), pp. 496-511.

Simmie, James (1997) Innovation, Networks and Learning Regions, Regional Policy and Development Series, Regional Policy and Development 18.

Sloan, A P (1963) My Years With General Motors, Published: Sedgewick & Jackson, London

Small firms in Britain, Employment Department 1991, Published: H.M.S.O., 1991

Solow, R. (1957) Technical Change and the Aggregate Production Function, Journal: The Review of Economics and Statistics, Vol: 39, pp. 312-320

Steele, L (1989) Managing Technology, Published: McGraw-Hill - New York

Steward, F. and Conway, S (1993) Informal Networks in the Origination of Successful Innovations, Technological Collaboration: Networks, Institutions and States, ASEAT Second International Conference, Manchester, 21st-23rd April

Stevens, G (1997) A Review of the New Product Development Process within Wandsworth Electrical Limited, MBA Project - Aston University

Stinchcombe, A. L. (1990) Weak Structural Data (review of Mizruchi and Schwartz), Journal: Contemporary Sociology, Vol: 19, pp. 380-382.

Stone, E (1978) Research Methods in Organisational Behaviour, The GoodYear Series in Management and Organisations, Published: GoodYear Publishing Company, Inc.

Sudman, S. and Bradburn, N. M. (1982) Asking Questions: A Practical Guide to Questionnaire Design, Published: San Francisco Jossey-Bass

Sutton, R. I. (1987) The Process of Organisational Death: Disbanding and Reconnecting, Journal: Administrative Science Quarterly, Vol: 32 (4), pp. 542-570

Swan, J (1996) Professional Associations and The Management of Expertise, in Scarbrough, H. (eds) The Management of Expertise, Published: Macmillan Business, Chpt 5, pp. 123-149

Teece, D. J. (1992) Competition, Co-operation, and Innovation: Organizational Arrangements for Regimes of Rapid Technological Progress, Journal: Journal of Economic Behaviour and Organization, Vol: 18 (1), pp. 1-25.

Teece, D. J. (1997) Capturing Value from Technological Innovation: Integration, Strategic Partnering, and Licensing Decisions, in Tushman, M L & Anderson, P (eds.), Managing Strategic Innovation and Change, Oxford University Press, pp. 287-306

Thomas, M. M. and Jones, P. (1999) UK Results from the Community Innovation Survey, produced by Department of Trade and Industry (DTI) Office for National Statistics

Tichy, N. M., Tushman, M. and Fombrun, C. (1979) Social Network Analysis for Organisations, Journal: Academy of Management Review, Vol: 4 (4), pp. 507-519

Tidd, J., Bessant, J. and Pavitt, K. (1997) Managing Innovation: Integrating Technologica, Market and Organisational Change, Published: Wiley

Tushman, M. L. and Anderson, P. (1997) Managing Strategic Innovation and Change - A Collection of Readings, Published: Oxford University Press

Tushman, M. L. and Rosenkopf, L. (1992) Organisational Determinants of Technological Change: Towards a Sociology of Technological Evolution, Journal: Research in Organisational Behaviour, Vol: 14, pp. 311-347

Tushman, M. and Scanlan, , T (1981) Boundary Spanning Individuals: Their role in Information Transfer and Their Antecendents, Published: Academy of Management Journal, Vol: 24 (2), pp. 289-305

Twiss, B. (1995) Managing Technological Innovation, Fourth Edition, Published: Pitman Publishing.

Von Hippel, E (1988) The Sources of Innovation, Published: Oxford University Press, Oxford

Walker, G. (1988) Strategic Sourcing, Vertical Integration and Transaction Costs, Journal: Interfaces, Vol: 18, pp. 62-73

Wernerfelt, Birger (1984), A Resource Based View of the Firm, Journal: Strategic Management Journal, Vol: 5 (2), pp. 171-180

White, H., Boorman, S. and Breiger, R. (1976) Social Structure from Multiple Networks: I. Blockmodels of Roles and Positions, Journal: American Journal of Sociology, Vol: 81 (4), pp. 730-780

Whitley, R. D. (1993a) Business Systems in East Asia: Firms, Markets and Societies, Published: London, Sage.

Whitley, R. D. (ed.) (1993b) European Business Systems: Firms and Markets in Their National Contexts, Published: London: Sage.

Whitley, R. D. and Kristensen, P. H. (eds) (1995) The Changing European Firm, Published: London: Routledge.

Whittington, R, (1990) The Changing Structures of R&D - from Centralisation to Fragmentation, in The Strategic Management of Technological Innovation by Loveridge and Pitt (eds.), Published: Wiley & Sons, pp. 183-204

Williamson, O.E. (1975) Markets and Hierarchies: Analysis and Antitrust Implications, Published: Free Press, New York.

Williamson, O.E. (1981) The Economics of Organisation: The Transaction Costs Approach, Journal: American Journal of Sociology, Vol: 87 (11), pp. 548-77.

Williamson, O.E. (1985) The Economic Institutions of Capitalism, Published: Free Press, New York.

Wilson, I. (1996) The Strategic Management of Technology: Corporate Fad or Strategic Necessity?, Journal: Long Range Planning, Vol: 19 (2), pp. 21-22

Yin, R. K. (1994) Case Study Research - Design and Methods Second Edition, Applied Social Research Methods Series, Volume 5, Published: SAGE Publications

Zahra, S.A., Sisodia, R.S and Das, S.R. (1994) Technological Choices Within Competitive Strategy Types: A Conceptual Integration, Journal: International Journal of Technology Management, Vol: 9 (2), pp. 172-195