DESIGN INNOVATION NETWORKS:
CRITICAL FACTORS THAT CAN CONTRIBUTE TO SUCCESSFUL COLLABORATIVE DEVELOPMENT OF INNOVATIVE PRODUCTS

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ABSTRACT

My study starts from the assumption that, in the post-industrial economy, organisations are surrounded by increasing complexities in their external environment. The dynamic and unpredictable conditions of external environments cause internal instabilities which force organisations to find a survival strategy. Many studies suggest that the development of innovative products is an important strategy in this economy. However, it is a very high risk activity. To develop innovative products, many organisations, in particular small and medium-sized businesses, experience two main problems: (i) high, fixed costs and uncertainties during the product development process and (ii) the limitations of their in-house resources and knowledge. Based on the tensions between the dynamic changes and unpredictability of external economic and market conditions, and the problems and limitations of product development within organisations, my study suggests that organisation networks are helpful for the development of innovative products.

My study comprises two stages. First, it investigates both theoretical and empirical studies related to the concept of networks in different areas: philosophy, biology, system theory and socioeconomics. Based on the analysis of these studies, it suggests that collaborative networks of multidisciplinary organisations are helpful in the development of innovative products in the post-industrial economy. Secondly, my study focuses on the examination of key factors, the effects of each factor, and the level of mutuality of these factors within successful collaborative networks. Four successful collaborative networks created for the development of innovative products within the UK during 1997-2003 are qualitatively examined. The main research focus concerns the structural relations between the collaborative organisations, particularly the interactions between the main points of contact.

The research findings suggest sixteen key factors, and nine out of them emerge to be dominant: (1) mutual trust, (2) equal valuing of working role, (3) clear agreement of the collaborative benefits, (4) an effective communication protocol, (5) flexible collaborative product development, (6) open information sharing, (7) mutual understanding between the parties, (8) commitment at all levels, and (9) innovation culture of each organisation.

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PROLOGUE

The research methodology of this thesis acknowledges an interaction between my personal belief from a Thai cultural and religious background, my professional design perspective, and the existing challenging conditions related to the sustained development of (radical) innovative products in the post-industrial economy. An explicit inclusion of these factors indicates how my initial perceptions of western business practices were formulated. It also serves to highlight issues that might subsequently inspire helpful changes in the way companies work in either or both cultures.

Challenging conditions of firms in the post-industrial economy

The nature of the post-industrial economy has emerged from the intertwining combination of global scale competition and cooperation, the revolution of information technologies, and knowledge-information-driven developments (Drucker, 1998; Castells, 2001). Brian Arthur sees the globalised market as characterised by flux and change. He notes that patterns form and dissolve as an evolving complex system in which no global entity is in control (Arthur et al, 1997). In such complex conditions, organisations in many countries, inevitably the UK, are affected. Tony Blair (DTI, 2003, 3) mentioned that '...in an increasingly global world, our [UK] ability to invent, design and manufacture the goods and services that people want is more vital to our future prosperity than ever.' Many also suggest that in this context, innovation is crucial for business survival and growth (e.g. DTI, 1995; 1997; Peters, 1997; The Design Council, 2000). Product innovation is therefore needed as an essential part of business innovation, though it is a very high risk activity. For example, previous studies suggest that incremental product innovation that exploits the potential of an established design or introduces relatively minor changes to an existing product, has significant economic consequences for established firms and the industry

(e.g. Utterback, 1994). On the other hand, radical product innovation, such as introducing radical developments of an existing product, frequently opens up new potential applications and whole new markets, can destroy the leading position of well-established firms and industries, and even leads to the creation of a new industry (Utterback, 1994, Hamel and Prahalad, 1994, Christensen, 1999). Some suggest organisations need to balance these two strategies (Utterback, 1994; Goffin et al, 1999). However, radical product innovation is likely to keep firms ahead of competitors and provide longer-term benefits (e.g. Utterback, 1994; Christensen, 1997, 1999). Essentially, my study argues that organisations need to find an appropriate approach to sustain radical product innovation in order to survive, and to grow in the current unpredictable, global economy.

My professional designer perspective

Based on my professional experience as an industrial designer, I see design as a central player within product, business and industry innovation. Since the 1980s, particularly in the UK, design has increasingly been promoted as an essential function in the creation of industrial products and business innovation (e.g. Roy et al, 1998; The Design Council, 1998; Trueman, 1998; Bruce et al, 1998; Bessant, 2002). For example, a study of Bessant (2002) indicates that design plays a significant role in the national economy and in the competitive advantages of individual firms, in particular when firms have to search for more subtle ways and value-added benefits which distinguish their products from their competitors. Bessant also suggests that design investment has a positive impact on companies' sales figures and profits. He points out that it can also affect companies' reputation and cause a change in customer and shareholder value. The UK Design Council (1998, 3) also suggests that 'using design effectively enables companies to increase the perceived value of whatever they are offering, as well as improving the efficiency of their organisation and systems.' Moreover, Trueman (1998) suggests that investment in design can increase profits and

market share, gain a competitive advantage, provide a strategy to grow, and offer a way of introducing new products or services.

Here, design is not just a fanciful thing, but a developmental process. Innovation by design can initiate both incremental and radical product innovations; from revamping old, existing products, to initiating 'blue sky' product concepts. It is not necessarily based on in-house or external professional designers, but also 'non-professional designers', who can contribute different ideas and perspectives from both internal and external firms to design (Thackara, 1997). 'Creative, innovative, and effective design is usually the result of a process which involves more players and more factors than just the input of a designer. Without a good client and a good team, good design is rare.' (Thackara, 1997, 430) Therefore, I believe that the principles of good design emerge from a holistic view of an interaction of different perspectives. Also, good design is holistic design. It should be holistically thought, not particularly focusing on particular aspects, such as artistic appearance, manufacturing and production processes, or commercial benefits, but also end users, social issues and ecological concerns. It also should benefit all stakeholders, not only the economies of individual organisations, but also for humanity, society and the ecological environment. To summarise, good design is for the pleasure and contentment of the whole.

My cultural and religious background

My Thai cultural and Buddhist background is the main motive for my research question. I was acculturated into the principles of the true nature of existence – the law of uncertainty, nonlinear cause and effect (Karma), flexibility and adaptability, and flux – and a harmonious way of maintaining an altruistic life: living together, helping and sharing each other and consideration for others. This leads me to hold the Thai Eastern belief of the ideology of 'harmony/cooperation' that all things are relational and cooperative for the balanced whole, opposing to

the competition/conflict approach which is, generally speaking, dominant in the West. It is worth noting that my belief in harmony should be taken as a pragmatic/optimistic, rather than idealistic approach. This is because the harmonious approach is based on the understanding of the true nature of existence according to the Buddhist principle, not the belief in an idealistic world view. It is also based on voluntary, organic and/or norms, rather than absolute, control and/or obligatory rules. Therefore, my harmonious approach is different from the ideology of a communist bloc: standardising, controlling, and/or cohering the entire actions for the common good by a central power. Neither is it based on the ideologies of industrialism, broadly speaking, mechanising, systematising and regulating production as a mechanistic system without a real understanding of how the balanced relation of the whole is organised and the complex, dynamic processes of the whole system relations and interactions. Nor is it based on an ideology of altruism in an ethic of universal compassion and the selfless ideal: concerning others' happiness more than one's own. Instead, my harmonious approach is rooted in the real understanding of existence, the balanced relation of the organised whole, and the processes of relating and cooperating. Each element is part of, depends on, relates to, and/or cooperates with one another, both directly and indirectly to sustain the balanced whole. It is my hypothesis that a greater prosperity for the global economy and society may emerge from a more harmonious approach rather than an approach of conflict.

The conflict/competition approach is the dominant idea of *laissez-faire* economics in global economy. The *laissez-faire* ideology focuses on the productive benefit of the self-interested pursuit of gain, when left free of regulation, for the common good. This has led to a dominant view in which a diversity of individual interests and free competition between them is seen as the natural way for the economy – and therefore society - to flourish. Although this competitive approach has created prosperity in the Western society over hundred of years, I argue that it is

unlikely to sustain the prosperity of firms operating in rapid changing, complex conditions of global, post-industrial economy, particularly to continuously create radical innovative products. The two main arguments that I will use to suggest that my harmonious approach is likely to be more conducive than the conflict approach I will infer by explicating at both short-term and long-term levels.

First, taking a short-term perspective of individual enterprises, to continually sustain radical product innovations, organisations face these main internal problems: high, fixed costs, internal risk of uncertainties during the product development process and the limitations of their in-house resources and knowledge. These problems constrain organisations from pursuing their radical innovations and business opportunities with creativity, flexibility and speed. In particular, with the constraints of in-house resources and knowledge, many suggest that SMEs tend to be more constrained than larger firms (DTI, 1999; 2002; CBI, 2002). Hamel (1999) suggests that, in spite of their economic power, most large firms are still constrained by their rigidities of their deep reservoirs of resources and assets, infrastructures and business models. These are a hindrance to change. However, most SMEs are limited by the lack of appropriate financial sources and skilled personnel (Cosh and Hughes, 2000, 2003). In short, these problems imply that individual firms, in particular SMEs, have great difficulties in dealing with a sustained flow of radical product innovations that lead to their new economic value.

Secondly, on the long-term perspective, a strongly competitive approach is unlikely to be optimal for economy and society in the long-run. It tends to fragment industry into a diversity of specialised enterprises that duplicate tasks among competitors in which competitive duplication of specific goods or services is generating more waste, such as wasteful consumer practices and natural resources. It also tends to build up selfish individual behaviour and a greedy

economic culture in which business tends to maximise one's own advantage, without concern for the realistic optimism of cooperation. Using the scenarios of Prisoner's Dilemma in game theory as the analogy, where the game is played repeatedly, the conflict approach tends to generate a 'win-lose', not a 'win-win' situation, or a 'zero-sum', not a 'non-zero-sum' result, which is unlikely to be optimal for the long-term *environmental* sustainability for business survival. Moreover, it tends to focus on deductive reason, what Robinson (2001) called 'septic focus', in which business concentrates on a specific point, a linear cause and effect, that often solves one problem and generates others, or generates a positive result alongside other negative consequences. Ecological problems affecting our human welfare, such as the Greenhouse Effect and pollutions, are the current example. Furthermore, it tends to focus on individual efficiencies by using mechanistic forces, rather than understanding the natural power and dynamics of relating and working together for the benefit of the whole group. Although this capitalistic, competitive endeavour claims a high record of efficient performance, being suitable for 'mass' production and generating surplus value for consumers (such as a diversity of product choices and lower cost of goods), my study argues further that it is unlikely to be adaptable, flexible and responsive to the nature and complex conditions of post-industrial economy, in particular where the dynamics of innovations, for example, in technologies, products, markets, and businesses, could destroy the capabilities of established firms and industries (Schumpeter, 1950; Utterback, 1994; Hamel and Prahalad, 1994; Christensen, 1999).

As mentioned above, my hypothesis was informed by my cultural background, and that this informed my research questions applied in a western culture. Based on the importance of sustaining radical product innovation for business, the organisation barriers of innovations, the inappropriate economic culture for long-term sustainability and my awareness of good design process, my thesis argues

that, in nature and complex conditions of post-industrial economy, organisations should network with each other in appropriate ways to sustain a flow of the development of innovative products. The harmonious approach or networks of innovation tend to be the only suitable option for many organisations, particularly small and medium-sized enterprises (SMEs).

My study focus

My study focuses on the collaborative networks of multidisciplinary organisations in the development of innovative products for manufacturing industry, which are mainly based on the experience of UK organisations.

I have framed 'product development' in a way that emphasises the design aspects. In this study, design is represented as a developmental process that uses social interaction to enable organisations to develop innovative products. I have therefore taken a broad view of the design process, assuming that it is not only the product of in-house or external professional designers (e.g. industrial or product designers), but also the outcome of deliberative social and communication processes among stakeholders or multidisciplinary professionals. As a result, internal and external professional designers are not a primary focus of this study.

By 'innovative products', I have not included products that were produced by making small or minor improvements to existing products, but rather, either existing products that were significantly improved or radically changed, or new products that represent a radical innovation (please see different types of innovative products in Section 1.3).

'Collaborative networks' are defined as the system in which the networking organisations interact and relate together as a collaborative team. In this team,

communication, information, power and authority are distributed more or less equally. The collaborative team comprises multidisciplinary organisations in which a group of different organisational experts are working together: for example, broadly speaking, design-manufacture-university collaboration or technology-manufacture collaboration, not manufacture-manufacture collaboration or design consultancy-university collaboration. This is because many studies suggest that the use of multidisciplinary teams is an essential factor in managing innovation success (e.g. Rothwell, 1972; Cooper, 1979; Freeman, 1986; Brunel University, 2000).

In this study, I have explored collaborative networks mainly at the micro scale rather than at the macro scale. This is because I was interested in the attitudes and relationships within collaborative networks that developed among multidisciplinary organisations, and which play some part in creating innovative products, rather than small or medium-sized enterprises in generating the economic prosperity of regions, districts or industries. What I shall refer to as a 'micro system' is a self-organising networking team of independent, multidisciplinary organisations which temporarily interact and work together to achieve a particular goal, and will, more often than not, disband once the goal is met. Because of the attributes of the micro system, it will be fluid and flexible (Bryne et al, 1993). This evolving micro system could emerge everywhere, not particularly in the same district, industry or region, but across districts, regions, industries and/or countries. My examples of the micro system are: strategic alliances between Cambridge Consultants Limited (Design and Engineering Consultancy) in the UK and the German Institute of Microtechnology Mainz, who worked together to exploit micro-medical technology and develop medical devices for healthcare products. BAE Systems worked with a number of external specialists, such as universities and oversea manufacturers to develop the Silicon Gyroscope.

In contrast, the macro system refers to the dense, complex networks of social and professional relationships which are supported by the region's or district's cultural and geographical atmosphere and/or institutional and technical infrastructure. My examples of a 'macro system' are innovation systems within industrial districts or regional clusters, such as the Cambridge and Oxford regions, German Baden-Württemberg, US Silicon Valley and the Italian industrial districts. Interfirm networks, in particular SMEs, often play an underlying part in sustaining the economic prosperity of a region (Keeble et al, 2000) and firms' innovation performance (Lawson, 2000; De Propris, 2002). Each macro system tends to have a unique behaviour and culture. The outcomes of innovation systems range from minor to radical changes within products or technologies that depend on clusters or regions. For example, Italian industrial districts, generally speaking, comprise small-scale, craft-based production units integrated by business practices, and guided by trust-based governance (Lazerson, 1988). Because they produce established products in mature industries (such as shoes, knitwear and bicycles), they tend to mainly generate creative or minor improvements within products. By contrary, the successes of Silicon Valley, California have built up more through the work of individual entrepreneurs, its technical and institutional infrastructure and the dense networks of social and professional relations, their working culture and geographical closeness (Rosenberg, 2002). Because this cluster houses new technologies in new industries (e.g. semiconductor and information technology), it tends to generate innovative spin-offs in comparison with Italian industrial districts. Though the dynamics of interfirm networks in the macro system is flourishing the success of regional firms and each region, district or industry, the danger of this system is the development of the locked-in conditions, such as efficient productivity, well-established specialisations, collective market identity, and strongly relating ties and culture (Perry, 1999; Castells, 2001). Whilst this system has reached the

mature, locked-in condition, it tends to be less fluid and flexible when radical innovations emerge outside the region or district. It is very difficult for the macro system to sustain a flow of radical innovative products, for example in the case of the mature industry within Italian industrial districts, because the market segment depends on the reputation by specialisation and quality (Perry, 1999). These network industries may also generate potential 'anti-competitive' effects which result higher prices for consumers or reduced innovation, output, product quality or related services (Jolly, 2003a, 4).

As a result, comparing the dynamics of the micro system with the macro system, which would be suitable for an uncertain, unpredictable and rapid changing environment, I argue that considering how things relate at the micro level is more conducive for firms to sustain the development of innovative products. I therefore decided to focus on the micro system. Also, this system permits me to delve qualitatively into better research information than the macro system, for reasons of great difficulty of the network case study methodology, the constraints of my research position as an outsider of the research topic, sensitive issues surrounding innovative product development, and complex nature of collaborative networks. Regarding the collaborative network at the micro system, I call it: 'contractual collaborative projects'. It is defined as the collaboration of at least two non-directly competitive, multidisciplinary organisations that are contractually committed to work together by means of sharing their efforts in the development of an innovative product.

What is new in my research?

My PhD thesis contributes the body of knowledge to both design theory and practice :

- For design management and studies theory, it establishes an epistemological theory of a creative network system for innovation in complex environments

and adds more new knowledge upon the previous studies of Bruce et al (1995) and Sale and Wilkinson (1999).

- For practical recommendations for design and product innovation management to industry, it suggests a set of key factors and aspects and 'solution-based guidelines' which help the collaborative partners to uphold the effectiveness of relations and cooperations within the collaborative network of multidisciplinary organisations in the development of innovative products.

Reviewing previous design studies and management that are relevant to product development and innovation related to the collaborative network at the micro level, I have summarised them into four categories.

The first category is the relationship between companies and external designers. The first relationship tends to have three engagements: subcontracting, collaboration, and 'blue sky' product ideas. The traditional engagement refers to the subcontracting of external professional designers to revamp companies' existing products. Designers are normally controlled by their clients. This engagement mainly generates creative outcomes or minor changes of existing products, such as the improvement of product appearance and function.

Secondly, the collaborative engagement refers to company-designer working together as a team during design process. The outcomes range from the improvement of the existing product, (for example, Tom Dixon worked with Cappellini, the Italian furniture manufacturing industry to produce, e.g. the "S" Chair and the Bird Rocking chair) to the creation of new products, (for example TKO and Monotub collaborated to generate a radical design of washing machine, the Titan).

Finally, designers are requested to come up with long-term, blue sky product ideas which are based on new technologies, materials, and new customer needs (Thackara, 1986); for example Cambridge Consultants Ltd and German Institute of Microtechnology Mainz developing healthcare products. This company-design relationship touches on the issues: the roles and benefits of external professional designers for product innovation (e.g. Bruce et al, 1998; Jevnakar et al, 1998), the management of client-designer relationship (e.g. Bruce and Morris, nd; Von Stamn, 1998; T. DeCesare, 2003), and the reflection of experience during the design academics-industry collaboration (Sale and Wilkinson, 1999; Rosenberg, 2000; Rothstein, 2002).

The second category explores organisation networks in co-designing and the way they utilise information and communication technology. There are many studies, each with their own particular concepts of collaborative design, such as electronic concurrent engineering/design across organisations (see Rodgers et al, 1999; Haymaker et al, 2000; Chen-Hsin Lui et al, 2002) and electronic data interchange within the supply-chain (see Rhodes et al, 1995; Woodcock et al, 1999). This category emphasises the innovative design process, tending to generate creative outcomes or minor changes of the existing product.

The third category looks at organisation networks through a governmental innovation scheme: the Teaching Company Scheme (TCS), a part-industry, part-government funded programme. The TCS is an opportunity for a company to take on a design graduate to develop new products or processes, or to improve quality, productivity and customer responsiveness with the full support of the University (see Inns et al 1998; 1999; Woolley, 1999).

The fourth category emphasises the relation between internal organisations and their external environment (e.g. ideas, information and knowledge). Based on

Udall's idea, named an 'open-systems' approach (see more explanation of this idea in Glossary), organisations should interact with their surroundings to import external creative energy to renew internal creative energy so as to stimulate continual innovation (Udall, 1999). In this approach, the term, 'open systems' refers to the system which the organisation responsively interacts with and relates to its environment with consciousness; not a totally open-ended social system that the organisation shares and communicates with surroundings without rules or concern for one's own position. Based on general explanation for management theory, it refers to the system that the organisation imports external creative energy (such as raw materials, new ideas, or skilled labour) and converts it into goods or services that are sent back to that external surrounding.

My study also endorses an open-systems approach, but proposes that organisations work in complex environments and should therefore work more reciprocally in designing innovative products. This view is supported by views and suggestions from fringes of biological theory, system theory, chaos and complexity theory, and social systems theory which define the dynamics of relating and interacting. These theories suggest a collaborative perspective of networking systems of interacting parts, their relationships, and the emergence of the whole interacting relations. Networks emerge from interactions among 'systems' (as agents, parts, cells, or organisations) and their environment. The emergence of networks, such as 'living', 'complex', or 'self-organising systems', is, by nature, complex and unpredictable partly because they depend on system-system and system-environment interactions. However, these theories argue that the attributes of the interactions and relations of self-organising networks are able to be 'open, responsive and adaptive' to changing environment (Waldrop, 1992). They also possess creative potentials; abilities to learn from perpetuating and mutually interacting of interrelating parts and abilities to innovate from their relating processes.

Based on these attributes of the network, my thesis offers a theoretical analysis of a creative network system, collaborative networks of multidisciplinary organisations in developing innovative products. In particular, it identifies ten key factors that underpin the success of the collaborative networks. In verifying the usefulness of these key factors, this thesis examines four selected network case studies of the contractual collaborative project using an in-depth, qualitative network study. These case studies were mainly based on the experience of UK organisations. The first two case studies were based in the UK. The rest were the international collaboration between UK organisations and other international firms. All are the multidisciplinary, cross-industry, collaborative projects which generate innovative products.

Regarding previous studies in the area of the identification of key success factors related to new product development (NPD), in the last fifty years, many studies have mainly focused on the identification of 'significant', 'critical', 'key', or 'successful' factors in the success of (i) NPD management (e.g. Carter and Williams, 1957; Langrish et al, 1972; Rothwell 1972; Cooper 1983; Cooper, 1993), (ii) innovation management (e.g. Twiss, 1992; DTI & CBI, 1994; Brunel University, 2000; Tidd et al, 2001), (iii) cross-functional teamwork or integration in NPD (e.g. Hauptman and Hirji, 1999; Holland et al, 2000), and (iv) cross-functional collaboration in NPD (Jassawalla and Sashittal, 1998). These studies have paid attention to success factors, in particular to improving the efficiency of new product development and innovation within organisations.

Regarding my research focus, the identification of critical factors within the success of collaborative networks of multidisciplinary organisations in the development of innovative products, little comparative work exists with mine (Bruce et al, 1995; Sale and Wilkinson, 1999). These studies identified significant

success factors in managing collaborative product development for individual organisations as part of their studies (please see the detailed explanation of each previous study in Section 3.2). In particular, Sale and Wilkinson (1999) identified significant issues in setting out the conditions for managing an interdisciplinary and cross-sectoral networked partnership to new product development. They reflected upon key issues from their experience as a design-acedemic partner. My thesis has a focus which is different from the previous studies. Instead of using a reflection of a participant perspective, either from the direct participation or the quantitative survey, my study uses the qualitative research method, named the 'network case study'. The research findings are based on the reflection of the collaborating participants within the project. Based on Fuller's theory of synergy (Fuller, 1975), understanding the relationships of the whole system tends to reveal the underlying factors, behaviours, structure and dynamics within the collaborative network.

CHAPTER 1: INTRODUCTION

INTRODUCTION TO CHAPTER 1

Chapter 1 describes the background of the study thesis. The study thesis has emerged from the interplay of three main strands: my personal belief, my point of view as an industrial designer towards designing innovative products, and the existing problems relating to any organisation in the development of innovative products in the post-industrial economy. Chapter 1 explains the entire process of the study investigation. It comprises the following sections:

Section 1.1 describes my personal belief which shapes my attitude, viewpoint and vision to design a better system in the development of innovative products in the post-industrial economy.

Section 1.2 describes my professional view as an industrial designer, which suggests that organisations should have a holistic approach in designing innovative products.

Section 1.3 clarifies areas of the study focus. This includes the description of design, innovative products and organisations.

Section 1.4 describes the existing contexts surrounding any organisation in the development of innovative products in the post-industrial economy. Five main existing issues are identified: (i) the context of the post-industrial economy, (ii) the necessity of innovative product development in this economy, (iii) the importance of external complex conditions (both threats and opportunities), (iv) diversity of external conditions, and (v) the intrinsic problems of innovative product development within organisations.

Section 1.5 describes the study argument; organisations should network with each other in the development of innovative products.

Section 1.6 describes the study aims.

Section 1.7 describes the study scope. The study scope consists of two main parts: the review of the existing theories and the investigation of the empirical network case study.

Section 1.8 illustrates the entire study process.

Section 1.9 describes the intended professional readership of the study thesis in order to provide context.

Section 1.10 describes the limitations of the study, in particular during the investigation of the empirical network case study.

Section 1.11 identifies the summary of the thesis chapters.

1.1 MY PERSONAL BELIEF

Regarding my cultural background, I believe in the rule of nature and that we should aspire to the concept of sustainable life. In Buddhism, we believe in the flexibility and adaptability of ourselves. Buddhism also teaches us to understand the law of uncertainty. Nothing is certain, except uncertainty. Nothing is permanent, even the self, no-self (Anatta). Life is only a fleeting union of cosmic elements that are constantly in flux. Also, in Thai culture we pursue the concept of an altruistic life, such as living together, helping each other, sharing with each other, and consideration for others. This culture is based on Buddhist's four infinite attitudes: (i) friendliness (Metta), giving pleasure and happiness to others; (ii) compassion (Karuna), understanding each others' pain and suffering; (iii) sympathetic joy (Muthita) over the happiness of others; and (iv) equanimity (Ubakara), freeing one from attachment to these attitudes so as to foster their impartial implementation. As a result, the interplay of my cultural background and Buddhist belief; the belief in the rule of nature and the concept of an altruistic life has underpinned my point of view, thought, logic, judgment and attitude, and shaped my vision to build up a better system in designing innovative products in the future. I envisage that to survive in the world of continual flux and uncertainty, everyone should co-operate together, help each other and empathetically understand each other. From this, I reach the conclusion that designing should be a collective action and a shared responsibility.

1.2 MY PROFESSIONAL SELF

Based on my personal views, and from my experience as an industrial designer, I agree with Thackara (1997) that design is to make products which are different, rather than just products that look different. My belief is innovative industrial products should emerge from the logic of good design which should not be only

based on the concept of 'taste'. Bayley et al (1986, 290) suggest that the concept of 'good' design related to taste was born in the 1930s and came to be prominent in the 1950s when industrial production, by ascribing to particular moral attributes, was integrated into the existing value of taste. They argue that this led people become confused by the issue of good design because the modern movement did not recognise the importance of technology in the culture. Bayley (1983, 30) commented further that, in the 1970s, an expression of taste was still itself the concept of good design and that 'good taste was not sufficiently broad a concept to acknowledge the reality of the world of the modern, international consumer'. I agree with Bayley and argue that good taste is not sufficient for an expression of good design, especially at the 21st century. In particular, the concept of good design is only based on beauty, style and fashion.

As our culture and society change, the concept of good design is also evolving. The developments perhaps depend on what influences design. For example, Bayley et al (1986) mentioned that the industrial revolution started in the 19th century created the structural change in manufacturing and production processes, the division of labour, market structure, and including design. This revolution brought a new approach to design; from individual production of craftsmen and artisans and artists, to complicated and sophisticated mass production of the division of labour and manufacturing processes. It also created a new concept of market; from personal or customised needs to more abstract demands or a mass, amorphous body of consumers. They (1986) further suggested that the modern designer came into being as an intermediary between industry and commerce. The designer's role was to improve industrial products to the mass market; perhaps to make them more durable and useful and more appealing and commercially successful. As a result of the conditions of industrial society, the concept of good design was modified by not only focusing on good design in

artistic sense, but also concentrating on the value of the product, manufacturing and production processes and market.

At the dawn of the 21st century, the concept of good design is increasingly challenging. The concept of good design in the industrial era, as mentioned above, may not be entirely satisfactory. This is because there are many rising issues that should be taken into consideration in good design, for instance: users' needs, pleasure and emotion, new material and technology, and our sustainable environment. I believe, therefore, good design is based on a holistic approach. First, good design should emerge from development and social process of an integration of different perspectives. It is not necessarily based on professional designers, but also 'non-professional designers', who can contribute different ideas and perspectives from both internal and external firms to design (Thackara, 1997). As Thackara (1997, 430) suggests that 'creative, innovative, and effective design is usually the result of a process which involves more players and more factors than just the input of a designer. Without a good client and a good team, good design is rare.' Secondly, good design is based on a holistic design. It should be thought inclusively, based on an integration of relational factors, not particularly focusing on particular aspects. The holistic design includes not only artistic appearance, manufacturing and production processes, and/or commercial benefits, but also end users, social issues and ecological concern. It should benefit all stakeholders, not only the economic benefits of individual organisations, but also humanity, society and the ecological environment. I do suggest that good design is for the pleasure and contentment of the balanced whole. In this regard, I have considered the views of four exemplary designers who, in different ways, reflect the concept of holistic design:

First, Papanek (1971) has commented on designed products since the 1970s, citing that designed products should not just touch a superficial surface of human

wants and desires, but also be aware of the permanent value of social needs and our ecological environment need.

Secondly, Bayley (1983, 31) suggests the principles of good successful design which are revealed certain qualities in common from the review of the history of Taste from the end of the seventeenth century to the end of the twentieth century:

(1) An intelligibility in the design form, so that its purpose can be understood

(2) A coherence and harmony between the form and the details

(3) An appropriate choice of materials to the function

(4) An intelligent equation between construction and purpose, so that the available technology is exploited to the full

Thirdly, Marzano (1998, 15), Director of Philips Future Lab Design, suggests design ethics for innovative products in the future which emphasise a holistic view in designing by citing the following issues:

(1) Design should give customers good products with relevant value for their money.

(2) Design should abandon our obsession with adding extra functions and fancy gadgets to products.

(3) Design should enhance the quality of consumer experience by making products easier to use.

(4) Design should concern the life-cycle of products.

(5) Design needs to replace the 'use-and-throw-away mentality'.

(6) Design should make products more 'user-friendly' by restoring the friendship between consumer and product.

Fourthly, Rams, the former director of design for Braun, mentions the holistic view of good design which has been the underlying design philosophy for Braun's designed products since the 1960s, as the following ten principles (referred by Kristensen 1998, 231):

(1) good design is innovative

(2) good design enhances the usefulness of a product

(3) good design is aesthetic

(4) good design makes a product understandable; its form follows its function

(5) good design is unobtrusive

(6) good design is honest

(7) good design is enduring

(8) good design is consequent down to the last details

(9) good design is ecologically conscious

(10) good design is minimal design

Rams (2001, 131) further comments on the holistic view of a new design ethic that, 'in the future, the value of design must be judged on the contribution it makes to survival in the widest sense.... The "purchase-attraction" aesthetic upon which design today is almost exclusively based ... will give way to an aesthetic which supports long-term use and the conservation of resources.'

Based on these exemplary views, the holistic design is inclusive. It should include the following issues (i) focusing on the permanent value of our human and social needs, (ii) concerning our ecological environment, and (iii) concentrating on the value of an end product –giving customers' value, enhancing design intelligibility and the quality of consumer experience, and enduring life cycles of products.

From this, I urge that, in designing innovative products, organisations should implement the holistic approach as the principles of good design: both an

integration of different perspectives and an inclusion of relational factors. As Bayley (1983, 31) pointed that the principles of design are 'the Rules of Taste' and 'Taste is the same as manners'. Inspired by Bayley, I suggest that the principles of good design are the Rules of design manners. This means they are not the legitimate rules, but rather the good manners that organisations should follow in future.

1.3 AREAS OF THE STUDY FOCUS

The area of my study focus is design management, in particular the collaborative development of innovative products between/among multidisciplinary organisations. Based on this focus, three key aspects need to be defined: (1) design as development, (2) innovative products, and (3) organisations.

1. DESIGN AS DEVELOPMENT

In this study, the position of design is defined, in a wider context, as part of innovation. Design is a developmental process. In this regard, I have considered the views of three authors who, in different ways, reflect design as a development process. Gorb and Dumas (1987, 162) states that 'design is a course of action for the development of an artefact or a system of artefacts; including the series of organisational activities required to achieve that development.' Thackara (1997, 31) also describes that '...design comes in as an instrument of innovation; design is a process that transforms raw technology into products or processes that people can actually use.'

As a result, the meaning of design is differentiated from a number of design studies which define it as an end product which resulted from, was created by, or co-operated with, professional designers (e.g. Bruce et al, 1998a). I have therefore taken a broad view of the design process, assuming that it is not only

the product of in-house or external professional designers, but also the outcome of deliberative social and communication process which involves more professionals and more factors than just the input of a designer. Accordingly, internal and external professional designers are not a primary focus of this study.

2. INNOVATIVE PRODUCTS

The UK Department of Trade and Industry (DTI) defines innovation as 'the successful exploitation of new ideas.' Crawford (1997) defines it as 'the act of creating new products and process and delivering at least some degree of newness to the market.' Regarding these two definitions, my study defines innovative products as those which successfully demonstrate and deliver with at least some degree of newness to the market. The newness degree of product innovation, broadly speaking, is divided into two categories: incremental product innovation and radical product innovation. The incremental innovation introduces relative minor changes to existing products or product lines, such as the improvement of product appearance and/or performance, and exploits the potential of the 'dominant design' (Utterback, 1994) which has well-established features and meets most user requirements in the market, such as cost reductions and repositioning of the dominant design. The radical innovation includes breakthrough innovation and major radical innovation. Breakthrough innovation or new innovation to the world introduces new inventive features (e.g. digital technology), or new products initiated by an innovative integration of new ideas and knowledge from different areas (e.g. the first PDA and MP3). Major radical innovation introduces a creative combination of very different sets of product attributes to a marketplace than the ones that normal customers historically have valued (e.g. Sony's early transistor pocket radios and remote controlled lights), or radical shift of the established products by introducing a different set of scientific and engineering principles (e.g. Silicon gyroscope and electric or solar power vehicles).

For the reasons of significance towards organisations in manufacturing industry, by 'innovative products', I have not included existing products that were produced by small or minor improvements or changes, but rather products that have been significantly improved or radically changes, or new products that represent a radical innovation. By this, I refer specifically to innovative industrial products, not innovative processes or services, due to my interest and professional experience as an industrial designer.

3. ORGANISATIONS

Drucker (1993) defines organisations as a human group composed of specialists working together on a common task, and specialised for and defined by its task. Udall (1999) suggests that each organisation is unique. An organisation of people can never ontologically be similar to each other. Even if organisations were to share the exact same workforce, the agent or purpose which binds them together is its differentiation. They manifest themselves through the mediation of a physical, social, intellectual, emotion or spiritual offer.

Based on these two views, my study does not focus on organisational scale which is only defined by the number of employees. The European Network for SMEs Research (ENSR), Small and Medium sized Enterprises (SMEs) employ 3 categories: micro enterprise (0-9 employees), small enterprise (10-49 employees) and medium enterprise (50-249 employees). Large enterprises employ over 250 employees. This study is restricted to the discrete specialties of organisations, such as manufacturing organisations, design consultancy, high-technology firms, governmental agencies, educational institutions and marketing research-led enterprises.

1.4 MY STUDY BACKGROUND

Five existing issues surround the development of innovative products in the context of the post-industrial economy: (i) the nature and conditions of the post-industrial economy, (ii) the necessity of innovative products, (iii) complex changes of external conditions, (iv) diversity of external conditions, and (v) the intrinsic problems of innovative product development within organisations.

1.4.1 THE CONTEXT OF POST-INDUSTRIAL ECONOMY

The term, 'post-industrial economy' relates to other terms, such as 'post-modernism' (Jencks, 1996), 'post-capitalist society' (Drucker, 1993), 'the third industrial revolution', 'information-based economy' and 'knowledge-based economy' (Drucker, 1993). All, in different ways describe the end of a more or less homogeneous industrial economy which fragmented after World War II. This section will describe the nature, implications and conditions of the post-industrial economy. It also draws on the influence of this economy towards the domestic economy, particularly in the UK.

1.4.1.1 NATURE AND IMPLICATIONS OF THE POST-INDUSTRIAL ECONOMY

After the Second World War, the nature of the economic system, domestically and globally, changed drastically. Castells (2001) suggests that the distinctive nature of the post-industrial economy emerges from the historical relation of the revolution of information technologies, the knowledge-information base of the economy, its global scale reach, and international corporations and alliances, which have increasingly become apparent since the last quarter of the 20th century. This inevitably implies new, different approaches to an individual, an organisation, an industry and/or a nation. Reviewing so far, the intertwining combination of four core characteristics of the post-industrial economy has emerged: it is global, informational, knowledge-driven and networked.

First, the post-industrial economy operates on a global level because, as Jolly (2003a) suggests, the declining of computing, communications and transport costs, coupled with the regulatory reform and trade and investment liberalisation, have prompted more globalisation strategies. 'The core activities of production, consumption, and circulation, as well as their components (capital, labor, raw materials, management, information, technology, markets) are organised on a global scale, either directly or through a network of linkages between economic agents [firms, regions, or nations]' (Castells, 2001, 77). This suggests that regional economic system and local businesses are greatly affected by their relationship to the global economy. Drucker (1998, 153) points out that 'the distinction between domestic and international economy has ceased to be economic reality –however much it remains political, social, cultural and psychological reality.' Therefore, the global, post-industrial economy implies that businesses and nations need to understand the concept of globalisation: i.e. the global market, competition and trends. They need to develop economic policies and strategies that not only focus on internal or regional issues, but also a global aspect, so that they can understand the global-economy's demands and opportunities.

Secondly, the post-industrial economy is an information-driven economy, as Castells (2001, 77) explains, because 'the productivity and competitiveness of units or agents [firms, regions, or nations] in this economy ... fundamentally depend upon their capacity to generate, process, and apply efficiently knowledge-based information.' Plus, the use of information and communication technologies continues to drive business productivity growth (Jolly, 2003a). This economy is shifting powers from production to market information. It refers to the dynamics of market, social and cultural information which is constantly changing. Its structure has changed from being organised around the flow of things and

money, to becoming organised around the flow of information (Drucker, 1998). It is built around the flow of information, not only continuous changes of market information, but also technological, social and environmental information. Based on this characteristic, it implies that organisations need to restructure their structure and organisation to respond to constant changes of information. Drucker (1998) suggests that they must be organised for innovation. For example, 'organisations increasingly will have to plan abandonment rather than to prolong the life of a successful product, policy, or practice' (Drucker, 1998, 79). Producers will have to restructure their plants to respond to rapid changes of market information, i.e. 'flexible manufacturing' –organised around the flow of market information rather than around the flow of materials or money (Drucker, 1998). Also, focusing on reengineering companies based on internal flow of information is no longer enough. Companies need to begin to organise themselves around the flow of external information (Drucker, 1998). In particular, the structure and organisation of businesses are increasingly built around the flow of real-time market information on what goes on in the marketplace and where the ultimate customers take buying actions (Drucker, 1998). Moreover, Alfred Chandler, Harvard Business Historian, suggests that this economy is 'the economics of speed' that drives global markets, not the economics of scale. Companies need to become innovative by not only foster innovation but also know how to get innovations into marketplace quickly (Referred by Grupp and Maital, 2001, xv). Furthermore, firms are downsizing, concentrating on their core competencies and shedding non-core activities, and are becoming more specialised and adopting leaner and flatter business structures (Jolly, 2003a). They are outsourcing functions (such as research and development and market analysis) and, simultaneously seek synergy with other enterprises (Jolly, 2003a).

Thirdly, it is a knowledge-driven economy in which a new category of work emerges, called 'knowledge work'. Drucker (1998) suggests that the knowledge work is learning-based, requiring formal education or at least formal training, not experience-based as all manual work has always been. Knowledge workers or organisations require the ability to acquire and apply theoretical and analytical knowledge for earning opportunities and even for the survival (Drucker, 1998). This implies that education will become the core of the economy and society at large, especially a habit of continuous learning (Drucker, 1998). The performance of an organisation, an industry or a nation in acquiring and applying knowledge will increasingly become the key competitive factor (Drucker, 1998). It is suggested that 'the knowledge society will inevitably become far more competitive than any society we have yet known –for the simple reason that with knowledge being universally accessible' (Drucker, 1998, 236). Also, this economy implies that knowledge work increasingly becomes highly specialised because 'knowledge in application is, by definition, highly specialised' (Drucker, 1998, 237). Therefore, organisations require learning how to acquire additional specialties to become highly specialised so as to be productive.

Finally, it is a networked economy because, as Castells (2001, 77) mentions, 'productivity is generated through, and competition is played out in, a global network of interaction between business networks.' Cross-border strategic alliances, mergers and acquisitions (M&A) and electronic commerce are common paths for firms to internationalising research, operations and markets (Jolly, 2003a). More than before, exports and imports, mergers and alliances and other investments by multinational companies are interlinked intensively and multiply (Jolly, 2003a). This implies that this economy is moving towards the valuing of relationships: the relationship between organisations and individuals who work for them and the relationships between different organisations (Drucker, 1998). The trend towards firm alliances tends to be the means for business growth. In

particular, the growth of relationships which are not based on ownerships (such as M&A), but on partnerships (such as joint ventures and strategic alliances) is increasing (Drucker, 1998).

1.4.1.2 COMPLEX CONDITIONS OF THE POST-INDUSTRIAL ECONOMY

The conditions of the post-industrial economy are complex. Its complex conditions can be illustrated by the conflation of many studies which were conducted in the last decade or two. For example, Block (1990) studied the post-industrial theory, based on contemporary economic and social perspectives, in comparison with the industrial theory. Regarding Block's study, the post-industrial economy is based on the thought of 'historical discontinuity', where the industrial theory cannot adequately be used to explain the phenomena of post-industrial, social development. Block illustrated that, in the 1960s, there were three emerging trends which could not easily be understood and explained as part of the industrial society: (i) the decline of goods production (manufacturing, farming and mining) and the rising importance of service economy, (ii) the tendency of changes of organisation and working experience as a result of the arrival of computer-based automation, and (iii) the breakdown of the linear life course and the decline of patriarchy (Block, 1990, 10-11).

Also, Arthur (referred to by Waldrop, 1992), an economist, argues that our world economy has been long viewed as what it should be, rather than what it is, within some modern theories, such as economic determinism, Marxism, or neoclassical economics. From Arthur's observation of the existing conditions of the world economy in reference to Chaos Theory and Complexity Theories, he asserts that our world economy is strongly influenced by instability and trivial happenstance. Arthur describes the real economy as an evolving complex system; characterised by all spontaneity and complexity, where the market place is unstable, full of evolution, and upheaval, and where new products, technologies, and markets are

constantly arising and old ones were constantly dying off. Arthur found the concept of flux, change, the forming and dissolving of patterns in the real world economy which no global entity can control. Some regulation is provided by mechanisms of competition and coordination between agents (Arthur et al, 1997).

Jencks (1996), architect, critic and theorist, describes the socioeconomic conditions of the post-industrial economy as 'hybrid, dynamics and interrelations', which are affecting our nations, cultures, communications, products and design so that:

"Some nations are dissolving, and all national identities are hybridising. Cultural boundaries are now crossed easily because of increasing trade, ease of travel and immediate world communication. This has led to 'space-time compression', 'the global village', which miniaturises the earth spatially and temporally to the equivalent of a small town – perhaps even a computer console. The space and time necessary for a transaction, meeting or media event has imploded drastically while the speed with which capitalism forces styles to change and products to innovate has also modified our taste for change in schizophrenic ways." (Jencks, 1996, 224)

Also, Jencks states the following elements, such as production process, culture, business structure, products and design in this economy are described in terms of the state of incomplete change. There are a series of simultaneous slides from one situation to another:

"There is the partial shift from mass production to segmented production (from Fordism to Post-Fordism); the slides from a relatively integrated mass-culture to many fragmented taste cultures (minoritisation); from centralized control in government and business to peripheral decision-making; from repetitive

manufacture of identical objects to the fast-changing manufacture of varying objects; from few styles to many of genres; from national identification to both local and global consciousness." (Jencks, 1996, 224)

Moreover, Jencks suggests that different models of post-industrial organisations have sprouted, that are different from the traditional icon of the industrial organisation (large, vertical organisations) in the industrial economy. There are three main models: (i) small, fast-changing organisations that are networked by computer and other media, (ii) organisations connected with external suppliers to generate just-in-time production and flexible specialisation and (iii) an organisation such as Benetton that manages many such dispersed networks and engages in little, if any, actual production. Jencks argues that in this economy, post-industrial organisations and industrial organisations are tightly interwoven.

Capra (2002) describes the condition of the industrial society in the 21st century asserting that the enormous complexity has become a foremost characteristic. Capra (2002, 85) asserts that this enormous complexity causes a 'deep malaise' among business executives because 'they feel pushed around by global market forces and insecure in the face of turbulence they can neither predict nor fully comprehend.' Capra (2002, 85) describes further that 'the business environment of most companies ... changes with incredible speed. Markets are rapidly being deregulated, and never-ending corporate mergers and acquisitions impose radical cultural and structural changes on the organisations involved –changes that go beyond people's learning capabilities and overwhelm both individuals and organisations. As a result, there is a deep and pervasive feeling among managers that, no matter how hard they work, things are out of control.'

Capra addresses that, almost every aspect of our lives has been increasingly affected by complex systems, which were difficult to imagine in the last fifty

years, such as global trading, global broadcast systems, worldwide communication via information and communication technology, and automated factories. Based on these complex systems, Capra (2002, 86) says that '...there is a growing recognition that they have brought with them a business and organizational environment that is almost unrecognizable from the point of view of traditional management theory and practice.'

In short, although these authors depict the post industrial economy and society from different perspectives, their analyses correspond. Broadly speaking, I would summarise the conditions of the post-industrial economy and society, which distinguish from the industrial economy, as historical discontinuity, instability, dynamics, hybridisation, incomplete change, multifaceted interrelation, and complexity. Such conditions have generated the existing situation which is unpredictable and complex.

1.4.1.3 INFLUENCE OF THE POST-INDUSTRIAL ECONOMY IN THE UK

'The modern world is swept by change. New technologies emerge constantly, new markets are opening up. There are new competitors but also great new opportunities. ... This new world challenges business to be innovative and creative, to improve performance continuously, to build new alliances and ventures. But it also challenges Government: to create and execute a new approach to industrial policy.' (Foreword by the Rt Hon Tony Blair MP, Prime Minister in DTI, 1998a)

Based on the above statement, it is a clear message that UK firms and regions are inevitably affected by the global, post-industrial economy. This message has recently been repeated by preeminent persons in the UK, for example, Tony Blair (DTI, 1998a, 2003a), Gordon Brown (Moore, 2004), the Chancellor, and Lord Sainsbury (2004), Secretary of State for Science and Innovation. They send a

strong determined message that the UK needs to be able to compete with other major countries in the global marketplace. Based on the recent document of the UK DTI (2003, 8), Competing in the Global Economy: The Innovation Challenge, it indicates that UK firms are facing three main global challenges:

(1) Trade liberalisation and a rapid fall in transport and communication costs. This means the UK must increasingly compete against countries with well-educated labour forces and much lower labour costs. For example, in China, wages are less than 5% of those in the UK. In South Korea, labour costs are just over half UK levels, and the proportion of graduates in the working age population is almost identical;

(2) Scientific and technological discoveries are changing the world faster than ever before. For example, new waves of innovation are unleashed by developments in Information and Communications Technology, new materials, biotechnology, new fuels and nanotechnology. These developments create many chances for businesses to gain competitive advantage;

(3) Global communications, the 24 hours, 7 days of the week media phenomenon. This refers to new fashions, ideas and products spread across the world almost instantaneously, and also consumer tastes are changing faster.

The DTI (2003a) further remarks that these phenomena are arising on a scale and at a speed never seen in the past.

A clear example of the impact of global, post-industrial economy towards the UK economy is the decline of UK manufacturing industry. The global economy has gradually affected UK manufacturing industry since the mid of 20th century. The main rationale of the manufacturing decline is because it cannot compete in global markets. For example, during the period 1950 – 1973, the UK had a low growth rate of productivity in comparison with other nations, such as the US,

Italy, Germany and Japan (Castells, 2001, 84). Between the 1950's and 1970s, UK heavy manufacturing industry seriously failed in productivity because it was unable to compete (Booth, 2003). Moreover, the Confederation of British Industry (CBI) suggested that 'Britain's manufacturing sector sees no end in sight to the longest sustained decline in orders for half a century as a slowdown at home intensifies the impact of a moribund global economy' (reported by Elliot, 2003). Furthermore, the recent decline case of an automotive industry in 2005, MG Rover Group, suggests that it is very difficult for UK manufacturing to sustain and compete. Based on recent statistic data related to oil prices, input costs and interest rates, employment trend in manufacturing sector and a recent prediction of the Transport and General Workers Union, 'manufacturing in Britain could disappear over the next 25 years' (reported by Seager, 2005). Perhaps, the sustained decline may be because, for example, the rise of other powerful manufacturing nations, such as Japan and China; high cost in raw materials and production in comparison with other Europe and Asia; the retreat of the UK in the global economy (Drucker, 1998; Elliot, 2003); a lack of state aid (Moore, 2004); and/or UK firms focusing on a wrong strategy, as Prof. Porter and Ketels mentioned, 'competing on relatively low costs of doing business' (referred by DTI, 2003a, 8).

According to these global challenges, British industry has been urged to recognise the essence of innovation and raise its rate. Innovation is a new key challenge to generate UK prosperity. Tony Blair (2003) suggests that 'innovation ... is absolutely essential to safeguard and deliver high-quality jobs, successful businesses, better products, services for our customers, and new, more environmentally friendly processes' (DTI, 2003a, 3). Professor Michael Porter and Christian Ketels of Harvard University also point out that UK leaders in government and business face the challenge from 'a location competing on relatively low costs of doing business to a location competing on unique value and

innovation' (DTI, 2003a, 8). This innovation challenge has been a clear theme of UK policy-making since 1997. This can be traced by the publications of the UK DTI (e.g. Our Competitive Future (1998), A Science and Innovation Policy for the 21st Century (2001), Competing in the Global Economy (2003)) and the UK Design Council (e.g. Living Innovation (2000); Meeting of Minds (2001)), and other UK policies for promoting innovation, such as Link, TCS, Faraday Partnerships and SMART (see an introduction of each policy scheme in Glossary). These UK publications and policies clearly aim to implement the distinctive implications of the post-industrial economy as mentioned above: business partnerships, global competition, knowledge sharing and continuous learning.

1.4.2 THE IMPORTANCE OF INNOVATIVE PRODUCTS

Schumpeter (1950), one of the pioneers of entrepreneurship, first introduced the importance of innovation in his book, 'Capitalism, Socialism and Democracy', asserting that innovations can change the rule of the game and destroy existing industrial structures within industries. He suggested that innovation, such as new technology, can destroy the market positions of firms committed to the old one. From his point of view, innovations are likely to be a powerful mechanism in opening up market opportunities and changing economy infrastructure.

The UK DTI defines innovation as 'the successful exploitation of new ideas'. It is suggested that, within businesses, innovation is not limited on the creation of new technologies, but includes the constant search for a fresh or new idea or approach to any aspect of businesses, whether that is in new or existing products; new techniques, processes, businesses, or services; new strategies; or new ways of working (DTI, 1997; Afuah, 1998). Also, innovation comprises not only a degree of radical or breakthrough development, but also incremental improvements and adjustments. Many studies in the last decade or two have commented on the necessity of constant innovation in such uncertain and

complex conditions of the post-industrial economy that innovation becomes a crucial strategy to sustain organisations and support them to survive (DTI, 1995, 1997; Peters, 1997; Afuah, 1998; The Design Council, 1998; 2000). For example, during the 1990s, the UK DTI Innovation Unit initiated a series of annual innovation lectures to promote the importance of innovation within the UK. It invited business executives from successful companies (such as Sony, Marks & Spencer, Oxford Instruments, 3M, and Virgin) to promote the implementation of innovation within organisations and their business success. These lectures emphasise that the importance of innovation is the process of wealth creation. Peters (1997) suggests that constant innovation is the survival strategy in uncertain and complex environments. The UK Design Council (2000) suggests that the key to improve business performance is innovation. The UK companies that outperform their competitors introduce new and exciting products and services, and meet and exceed market expectation because they commit to innovation.

In particular, focusing on product innovation has been recognised by many successful organisations as an essential strategy. This assertion has been reinforced by a number of academic researchers and practical professionals (Roy, 1986; Clipson, 1991; Utterback, 1994; DTI, 1996b; Hollins and Hollins, 1999; Trott, 1998; Tidd et al, 2001; Bessant, 2002). They agreed that the continual innovation of new or existing products helps organisations to grow and survive. Clipson (1991) suggested that successful innovation can greatly improve the economic performance of companies, enhancing growth and profit rates. The study of 121 UK-based businesses by DTI and Warwick Manufacturing Group (1994) revealed that developing new products is a main driver in staying ahead of the competition. New products can also open up new business opportunities and promote organisations to be a leader in market (DTI, 1996b). Tidd et al (2001) studied the management of innovation from a vast number of successful

companies and suggest that, as the research evidence reveals a strong correlation between new products and market performance, innovation helps organisations retain and capture market shares, and increase profitability in those markets. Bessant (2002) studied the role of design in creating incremental improvements and adjustments of new or existing products in the last twenty years, and suggests that constant innovation through design has a positive impact for organisations' sales figures, profitability and exports.

Also, it is claimed that the degree of innovativeness correlated with the economic performance of organisation businesses and industries. According to previous innovation studies in different industries, such as consumer electronics, disk drives and advanced materials (Utterback, 1994; Hamel and Prahalad, 1994; Christensen, 1999), two main strategies are prominently suggested.

First, incremental product innovation introduces relative minor changes or improvements to the existing product or the 'dominant design' (see details in Section 1.3). It gives customers more and better value in the product attributes and also gives well-established or leading organisations in most industries strengthen their economic performance ahead of their rivals (Utterback, 1994; Hamel and Prahalad, 1994; Christensen, 1999). Though, this innovation does not have highly inventive solutions or radical changes, it often requires considerable skills and initiatives (Henderson and Clark, 2004). Well-established and/or leading firms, generally speaking, for example, operating in the automotive, fashion, digital camera and mobile phone industries, have currently employed this strategy to sustain themselves and the industry.

Secondly, radical product innovation introduces breakthrough innovation to the world or major radical innovation to a marketplace (see details in Section 1.3). Though these two strands of radical product innovation may often initially be

valued by mainstream customers, Utterback, Hamel, Prahalad and Christensen suggest that they, in particular the breakthrough innovation, potentially open up new potential applications or products and whole new markets. They often introduce great difficulties for well-established organisations and can be the basis for the successful entry of new firms. In particular, the breakthrough innovation is 'disruptive' innovation which can destroy the leading position of well-established firms and old industries, and even drive new one. It also changes the way firms and industries think about their organisations, managements, products, processes and so on. The innovation studies of Utterback (1994) and Christensen (1997) in the typewriter and disk drives industries confirm this argument by demonstrating the relationships between the adoption of an existing technology to develop the well-established product, the evolution within the industry and the competitive climate faced by individual firms within the industry. They also demonstrated the relationships between the emergence of breakthrough innovation, the beginning of new industry, and the successful entry of new comer.

Based on these two innovation strategies, the Utterback's study of industry development through several waves of innovation over 100 years indicates that 'established firms must occasionally attempt to renew and diversify their core businesses [radical innovation] rather than simply improve and expand their well-established products' (Utterback, 1994, xx). As mentioned by Roy (1986), Utterback (1994) and Trott (1998), the significance of radical change in the existing product or radical innovation is a source of competitive advantage that is far more important than the management of minor changes of the existing product. Organisations create radical innovative products show high growth rates and long-term benefits (Utterback, 1994; Hollins and Hollins, 1999). It is suggested that novel products have an effect on organisations' profits which can be large, positive and long-lasting (Twiss, 1992; Geroski et al, 1993). Perry (2001) reinforced this point by mentioning a recent study of 100 UK CEO's done

by PA consulting, that organisations relying on product line extensions show poor growth rates in comparison with companies that create novel products.

To sum up, constant innovation is a crucial strategy in the post-industrial economy. In particular, the development of innovative products, containing the radical/novel/highly improved degree of innovativeness, plays a critical part in the economic performance of organisations: sustaining growth and organisations' life, and providing long-term benefits and competitive advantages. Inevitably, the continual development of innovative products would be an essential strategy to sustain organisational growth and survival.

1.4.3 COMPLEX CHANGES OF EXTERNAL CONDITIONS

As mentioned in Section 1.4.1, the nature and conditions of the post-industrial economy are complex. To develop innovative products, organisations are inevitably facing external complex and uncertain conditions. Reviewing a number of recent studies (Robert, 1995; Biemans, 1995; Rzevski, 1995; Jencks, 1996; Marzano, 1998), my study identifies a list of diverse changes of the socioeconomic conditions of the post-industrial economy in comparison with the industrial economy, as shown in Table 1.1.

Table 1-1 illustrates the tendencies of post-industrial economy in comparison with industrial economy

ASPECTS	CHARACTERISTICS		SOURCES
	Industrial economy	**Post-industrial economy**	
Economic Structure	Push economy (demand > supply)	Pull economy (supply > demand)	Robert (1995), Rzevski (1995)
Market Characteristics	Market Segmentation, Producer-led market	Market Fragmentation, Consumer-led market	Robert (1995), Marzano (1998)
Product Characteristics	Generic product	Customised product	Robert (1995), Rzevski (1995)
Product-life Cycles	Long	Shorter	Robert (1995), Biemans (1995), Marzano (1998)
Manufacturing Process	Efficiency required, Mass production	Flexibility and effectiveness required, Segmented production	Robert (1995), Jencks (1996)
Production Run	Long production run,	Shorter production run	Robert (1995)
Innovation	Product innovation	Process innovation	Robert (1995)
Brand Loyalty	Strong product loyalty	Little product loyalty	Robert (1995)
Prices	Commodity prices	Premium Prices	Robert (1995)
Rules of Game	Fixed rules set by producers	Changing rules set by customers	Robert (1995)
Customers	Large, similar needs and simple demands	Smaller, dissimilar needs and sophisticated demands	Biemans (1995), Rzevski (1995),
	Predictable consumer behaviour	Unpredictable behaviour	Marzano (1998)
Competition	Low competitive market	High-competitive market, global	Biemans (1995), Marzano (1998)
Technology Pace	Slow changing, focusing on production	Rapid changing of new technology, focusing on new applications	Marzano (1998)
Organisation Value	Efficient production	Innovation	Jencks (1996)
Product attribute	Simple	Increasingly complex	Biemans (1995), Marzano (1998)

Table 1.1 shows fifteen aspects surrounding organisations, which impact on the development of innovative products in the post-industrial economy. For example, the change of economic structure from 'push economy' to 'pull economy' has generated the economic condition of 'a surplus of supply over demand' (Robert, 1995; Rzevski, 1995). Robert (1995) suggests that, in this economic condition, customers play a more critical and leading role than producers. They are increasingly making sophisticated demands upon their suppliers and products (Biemans, 1995). They demand both quality and low prices, and customised products and services (Rzevski, 1995). Also, there are an increasing number of competitive players and intensity of competition in the global market. Moreover,

new products are becoming increasingly complex, and their development needs the mixture of diverse areas of knowledge, such as design concept, production processes, user needs, market demands and trends, the existence of new technology, and product regulations. Marzano (1998, 5) predicts that products are changing 'from highly tangible, even cumbersome products to those that are tiny and barely more than packaged information.' Furthermore, the product life-cycle has shortened considerably. Biemans (1995) suggests that the shortened product life-cycle is driven by the acceleration of technological developments, particularly in advanced technology-led consumer products, such as computers. Biemans asserts that the life-cycles of these products are often measured by months rather than year. As a result, the reduction of time span to introduce new products to market becomes critical. In short, I would summarise that these changing circumstances are increasingly generating very complex conditions which impact on the way organisations create their innovative products. This is because these issues are not individually continual changing, but they are interwoven, affect each other, and generate continual changes as a whole.

1.4.4 DIVERSITY OF EXTERNAL CONDITIONS

As I observe, external conditions surrounding organisations in the post-industrial economy helped to introduce both threats and opportunities for developing innovative products.

1.4.4.1 THREATS WITHIN EXTERNAL CONDITIONS

Changing external conditions (as mentioned above) could be a threat to the development of innovative products. Reviewing a number of previous studies, I have considered the views of three exemplary design theorists who, in different ways, reflect threats of external conditions. Jones (1980) suggests three following external environments in design methods which could be barriers to innovative product development:

(1) The effects of new products and their production systems planning may distort decisions.

(2) The need for general standards of compatibility which require national, corporate or international standards, (e.g. safety regulations and other industrial standards) and which ensure compatibility between new products and interacting systems.

(3) The inertia of existing product systems which cannot be removed until a new emerging system will be reorganised.

Hollins and Pugh (1990) also cite the external context, referred to as macro factors which affect changes to either incremental or radical product innovation. Hollins and Pugh detail sixteen major factors and suggest five external factors that make products static:

(1) Existing product infrastructure, such as within the automotive industry. There is an existing design concept and the large industrial infrastructure which prevent organisations making radical changes of products.

(2) Performance standards –the relationship of one product with other products. A change in one design could affect those other products.

(3) Conformance standards –such as regular standards controlled by law. Such standards could restrict organisation's freedom.

(4) Customers not willing to change. Consumer preference for existing design is hard to change in many respects, such as tangible values (perceived value for money, usefulness, and ease of use) and intangible values (style, image and brand loyalty)

(5) Stable technology. There is the absence of new technological development which can improve existing products or solve existing product problems.

1.4.4.2 OPPORTUNITIES WITHIN EXTERNAL CONDITIONS

External conditions could also be opportunities for the development of innovative products. I have analysed a number of previous studies related to design and product development (Jones 1980; Hollins and Pugh 1990; Thackara, 1997; Marzano, 1998; Bull, 1999; Julier, 2000; The Design Council, 2000; Tidd et al, 2001). These studies show how external conditions affect the development of innovative products. In the light of these studies, I have summarised seven key external factors causing changes in innovative products:

(1) Rapid changes of new technology

(2) Globalisation: global competition and market

(3) Market fragmentation: increasing individualistic and consumers' customisation

(4) Changes of product environments -such as legislation, economic climate and product resources

(5) New issues of design innovation, such as user needs, product customisation, the improvement of quality of life, social trends and constraints of natural environment

(6) Shorter product-life cycles

(7) Increasing complexities of new products: future products tend to provide not only physical performance, but also carry knowledge, services and emotions.

In exemplifying beneficial opportunities of external conditions which are essential to the development of innovative products, I have considered the views of three professional examples:

First of all, Marzano (1998) predicted that product innovation in the future will quickly change in accordance with changes of external environments. He suggests five external factors:

(1) The fragmentation of the market (increasingly individualistic and consumers are complex, flexible and multi-dimensional),

(2) Globalisation (the prospect of globalised process and market),

(3) The product shifting to quality of life (in terms of making consumer experience richer and more meaningful, and increasing the product values which promote humanity's culture growth),

(4) Technology exteriorisation (new materials and advanced technologies),

(5) Product itself (future product must be a creator and carrier of knowledge, services, and emotions).

Secondly, Thackara (1997) studied new factors which have affected the design and development of successful innovative products within Europe. He indicated three main external resources which were contributing to the achievement of those designs. (i) Social changes included four main changes within European social structures: macro demographic change of aging populations, new family structure (one-parent families), changing consumer values, and new patterns of work. (ii) The market indicated four main issues: product differentiation, product customisation, product usability and safety, and environmental friendly products. (iii) Five new technologies are driving radical changes within the design of industrial products: technology and human body, microchips and smart materials, intelligent manufacturing, smart logistics, and Internet and on-line communications.

Finally, Brunel University collaborated with The Design Council to study creative ideas of design and innovation of the winners of Millennium Product Awards (2000). The study indicated new issues which derived from external conditions which the UK organisations obtained new ideas: social trends, new technology, user needs, and future trends. This study claimed that these would be prospective elements in the development of innovative products and/or services in the future.

To sum up, diversity of external conditions surrounding organisations generates both threats and opportunities in the development of innovative products. On the one hand, existing product infrastructure, general standards and compatibility, performance standards, customers not willing to change, and stable technology are perceived as threats. On the other hand, external factors, such as new technology, user needs, market demands, social trends and the limitations of ecological resources are also crucial opportunities as new ideas. Significantly, ignoring external conditions, in particular the specific requirements of the potential market, innovative products are less likely to succeed (Freeman, 1986; Biemans, 1992; Crawford, 1997; Franklin, 2002). As a result, external conditions become a vital part in the development of innovative products in the post-industrial economy. Products are modified and shaped by external conditions, not only by product itself and producers (organisations). The success of innovative products is likely to be a 'coupling process' (Freeman, 1986). Hence, organisations cannot only be concerned with their in-house knowledge and resources as the merely main focus to develop innovative products. They need to be adaptable to external diverse, complex conditions. Also, organisations need to have an insight into external conditions and turn them into innovative product opportunities rather than threats. Inevitably, organisations need to have an ability to connect, interact and co-produce with external conditions effectively.

1.4.5 PROBLEMS OF INNOVATIVE PRODUCT DEVELOPMENT

As I have observed, to continually develop innovative products as an essential part of the survival strategy, as mentioned in Section 1.4.2, organisations inevitably experience two main problems:

1.4.5.1 COSTS

It is widely recognised that managing or working on an innovative product development project is highly risky because of soaring costs and uncertainties.

Organisations involved in this activity cannot avoid these intrinsic problems. I have considered the views of five previous studies in the last twenty years which, in different ways, reflect these related problems. For example, Booz, Allen and Hamilton (1982) highlighted the issue of cost relating to uncertainty from their study on product innovation process. Booz, Allen and Hamilton mentioned that nearly 50 percent of all money invested in product innovation was spent on unsuccessful development activities. Also, Walsh el al (1992) studied the failures of radical innovative products, such as Advanced Passenger train and Sinclair C5, and concluded that the product innovation process is full of high risks. If the product fails, companies will lose their investment. Moreover, Ulrich and Eppinger (1995) demonstrated a variety of costs associated with different types of new products. They revealed that the more complex innovative products are, the higher costs and risks will be. Furthermore, the study from The Design Council (1998) revealed that, not only do innovative products involve considerable risks in investment, but they also involve uncertainties of markets and convincing customers to buy. Additionally, Home-Martin et al (2002, 15) studied six case studies of new product development within SMEs and suggested that risks are in critical decision points where there was the commitment decision during product development, that is, 'that decision to proceed from the initial stages of development to further product development.' Home-Martin et al indicated four types of risks: financial risks (risk of money loss), personal risks (reputation, loss of personal finances and disruption of personal circumstances), design risks (technical issues, safety and copyright), and sales risks (market demand exceeded expectations after the product launched).

1.4.5.2 LIMITATIONS OF INTERNAL RESOURCES

Reviewing so far, there is no clear evidence which directly confirm the links between the limitations of internal problems and the development of innovative products. Nonetheless, I have considered the evidence which is in the area of

innovation management where, to some certain extent, innovative products are a part of the innovation indicators. The evidence from the survey of the UK DTI indicated that all sizes of organisations/enterprises (except micro enterprises) have constraints on innovation (DTI, 2001a). The survey reveals that constraints on innovation that have led to delay, cancellation or prevention of particular innovation projects derive mainly from some of the internal or market factors, around 20% of the UK businesses. Next, roughly 50% lack of appropriate sources or cost of finance. Particularly, the DTI suggests that financial constraints are the most important constraint that high technology businesses are likely to encounter. Furthermore, the DTI asserts that shortages of technical and managerial skill are the next crucial constraints. Thus, these revealed constraints on innovation of all sizes of businesses are mainly from internal problems: financial constraints, and shortages of technical resources and managerial skills.

Although all sizes of businesses face internal constraints on innovation, in particular SMEs seem to have far more problems when compared with larger enterprises.

Qualitative data from Technology, Productivity and Job Creation, OCED (1966) indicates that 'large firms tend to employ more workers, have higher skill levels, pay higher wages and offer more stable prospects to their workforce which means that they have the power and the capability to innovate consistently' (quoted by DTI, 2001b). In spite of their economic power, most large firms are still constrained by their rigidities of their deep reservoirs of resources and assets, infrastructures and business models (Hamel, 1999). In contrast, Managing National Innovation Systems, OECD (1999) asserts that 'small firms tend to have more limited financial and human resources, less ready information and shorter time horizons. In addition, they are generally more risk averse and reluctant to engage outside help expect for the very specific short-term.' (quoted by DTI,

2001b). Hughes (2001) also confirms that innovators in the UK SMEs, during 1994-1999 reinforced this point that, on the one hand, their constraints on innovation are mainly labour skill, finance, and lack of management, marketing and sales skills. On the other hand, Hughes indicates that the weakness of the UK SMEs was the small number of their employees. Inevitably, these affect the UK SMEs performance towards innovation.

Moreover, the UK innovation survey of 2,344 enterprises, conducted by the office for National statistics on behalf of the DTI during 1994-1996, confirms that SMEs are less likely to innovate than larger enterprises. Based on this survey, the findings indicated that, based on the manufacturing sector, the number of SMEs' innovators are about 48 percent, whereas 83 percent are large enterprises (DTI, 1999). Innovators are defined as enterprise that introduced any technologically new or improved products, processes, or services. The study suggests that large firms were approximately three times more likely to be novel innovators than SMEs. The UK Innovation survey 2001 of almost 6,000 enterprises in four sectors: production, construction, distribution and services, covering the three year-period from 1998 to 2000, also suggested a similar outcome. The survey result indicates that 'large production and construction enterprises were three times more likely to introduce new or improved products than SMEs in the same industry' (DTI, 2002a, 38). Moreover, the 2002 UK innovation survey of over 400 companies in different sectors, conducted between January and March 2002 by CBI in the support of 3M and Design Council, suggested that, in comparison with larger firms, SMEs tend to have less potential to innovate (CBI, 2002). Based on the cluster analysis (a statistical method to classify large data sets by grouping individual cases that are relatively similar to produce clusters that are distinctive from one another), the CBI 2002 survey suggested that, in the cluster of 'Innovation Stars' (having high rates of innovative outputs), larger firms (55%) have a higher percent than SMEs. In the cluster of 'Lacklustre Innovators'

(significantly requiring a structured approach and significant effort to improve their innovation potential in all areas), SMEs (78%) have a percentage three times as high as larger firms. In the cluster of 'Moderate Innovator' (needing support to develop their innovation potential), SMEs (66%) have percentage a twice as high as larger firms. In short, based on these three surveys, organisation size is related to innovation performance.

Cosh and Hughes (2000, referred by Hughes, 2001) measured the main constraints of innovation performance experienced by innovators and non-innovators in meeting their businesses' objectives within the UK SMEs sector during 1997-1999. Innovation was measured by either too much or too little process or product innovation during that period. The result indicated that innovators felt more constrained in all dimensions than non-innovators. SMEs' innovators placed emphasis more on demand and labour skill constraints, and lack of management, marketing, and sales skills. The UK Innovation survey 2001 also indicated that SMEs encountered constraints while carrying out innovation activities as well as factors preventing innovation as the following factors: the direct resource costs of innovation activities and the cost and availability of finance, the lack of qualified human resources and information on technology and markets, and the impact of regulations or standards (DTI, 2002a). Moreover, the recent UK SMEs sector survey of 2,127 firms during 1999 - 2002 regarding product, process and logistic innovation respectively by Cosh and Hughes (2003) suggests that the main barriers to innovation identified by both innovators and non-innovators are lack of appropriate financial sources, innovation costs too high and a pay-off period too long. Amongst internal factors, the significant barriers are the firms lack of innovation activity and skilled personnel. A variety of regulatory factors (legislations, norms, regulations, standards and taxation) and lack of consumer responsiveness are also referred to as a very significant barrier. Cosh and Hughes suggest that 'this pattern is common across the EU.'

This UK evidence above portrays that all sizes of organisations, in particular SMEs have constraints on innovation performance. They are limited by their internal constraints: a number of human resources, a variety of knowledge and skills, financial resources, capital assets, and lack of management skills.

In Conclusion: Within the context of the post-industrial economy, including the nature, implications and complex conditions of the economic system, the importance of innovative products, complex changes of external conditions surrounding organisations directly related to product innovation, threats and opportunities of external conditions, the intrinsic problems of innovative product development, and limitations of internal organisation resources, these are putting pressures on all sizes of organisations, in particular SMEs to effectively manage the development of innovative products. Inevitably, organisations need to find a new approach. I suggest that organisation networks are a pathway to reaching this approach.

1.5 MY SUGGESTION

Von Bertalanffy (1969, xxii) refers to 'systems epistemology'. Systems epistemology includes the personal perspective of an observer on a particular subject. It has been acknowledged in the area of physics. I agree with Von Bertalanffy who describes the existence of the systems epistemology; that its existence emerges from an interaction between knower and known. Different perspectives of epistemology are built up by their different independent background, experience and knowledge. There are no ultimate entities of epistemology. Everybody is able to build up their perspective of knowledge because different people will see a thing differently. Each episteme has a clear identity of its own. Rooted in this proposition, I would suggest my epistemological

perspective which would be able to support organisations to survive and grow in complex conditions of the global, post-industrial economy. My perspective is built up through an interaction of my personal belief, professional self and the existing conditions related to the development of innovative products. I suggest that there is a viable possibility that organisations should network with each other in the development of innovative products in the post-industrial economy.

In clarifying this position, I strongly endorse a relational and cooperative viewpoint, or harmonious approach, rather than the pursuit of self-interest of individual organisations. My suggestion is rooted into my cultural background and the Buddhist ideology in the East (see details in Section 2.1). It is worth noting that my viewpoint should be taken as a pragmatic/optimistic approach rather than idealistic approach. This is because the harmonious approach is based on the understanding of the true nature of existence derived from the Buddhism principle, not the belief in a theoretical or idealistic world view. It is also based on voluntary, organic and/or norms, rather than absolute, control, and/or obligatory rules. My relational and cooperative viewpoint is the antitheses of the ideology of individualism and deductivism in the West.

The individual and deductive approach of the Western society has been shaped by the integration of the complex and interwoven changes of philosophical, religion, political, societal, cultural, scientific and technological developments and paradigm shifts over hundreds of years (Robinson, 2001). These intellectual horizons of the West started forming in the Renaissance during the 16th and 17th centuries when two key social themes are emerged: first, 'a new emphasis on the importance of individual experience', and secondly, 'a new faith in the power of reason as the true source of knowledge' (Ibid, 69). In this period, philosophers and intellectuals started asking questions about the nature of thing, especially 'what is knowledge and how do we know', and, 'in answering these questions,

they developed the intellectual methods and techniques...' (Ibid, 70). The Enlightenment was driven by the ideas of rationality (rationalism) and of evidence (empiricism). Robinson suggested that 'this period saw spectacular achievements in science and technology that led directly to the industrial revolution of the 18th and 19th centuries and to the dominance of science in all its forms in our own times' (Ibid, 71). Based on the example of these accumulated developments and progress, Robinson (2001, 72) mentions that 'they are part of modern ideology and they interact powerfully with how we think and create theories in every field.'

Inevitably, the individual approach also influences the ideology of *laissez-faire* economics, the dominant idea of capitalism in the 20th economy, rooted in the Smith's economic theory. Adam Smith inspired the economics of *laissez-faire* which claims offer a commercial phase of the theory of human history. In Smith's book, 'The Wealth of Nations', in 1776, Skinner suggested Smith's argument that 'a certain sanctity of self-interested pursuit of gain was productive of benefit to society at large, by demonstrating that the enterprise of individuals was capable, when left free of regulation, of carrying the standard of material well-being to heights hitherto impossible and scarcely calculable' (Skinner 1970, 11). According to Smith, the wealth of the whole economic system tended to be based on the reasoning of interdependence of exchanges between organisations depending upon the self-interested actions and reactions.

Consequently, I disagree and intend to argue strongly against the claim that all reasons for acting should be based on an individual viewpoint. A strongly individual approach is unlikely to be effective for individual firms to sustain their product innovation in the global, post-industrial economy. This is for the following reasons:

- Because of the dynamics of external information (e.g. market, social and cultural information) being constantly changing, and the dynamics of innovation (e.g. technologies, products and businesses) which could destroy the capabilities of established firms, flexibility and adaptability of firms are imperative. For this reason, it is suggested that firms are downsizing and tending to become more specialised and concentrated on their core-business abilities and activities (Jolly, 2003a). To create innovative products, they tend to require complementary intellectual capital (i.e. knowledge, information, intellectual property and experience).
- To sustain the development of innovative products, many organisations, in particular SMEs, are limited by the following internal problems on innovation performance: (i) high, fixed costs, (ii) uncertainties along the development process and (iii) the limitations of in-house financial and human resources, the variety of knowledge and skills, and capital assets.
- In developing innovative industrial products, organisations are surrounded by increasingly complex environments, as mentioned in Section 1.4.3. In particular, industrial products have become increasingly complex and their development needs the holistic approach: a mixture of diverse areas of knowledge and information and a collection of multiple experiences and perspectives.

Though the individual/competitive approach currently claims a high record of efficient performance in generating products' diversity, choices, and surplus value for consumers (e.g. lower cost of goods and good product quality), I question that it is unlikely to be optimal for the economy, society and ecological environment in the long-run as follows:

- For the economic system: the individual approach tends to build up selfish individual behaviours and greedy economic culture in which business tends to

maximise one's own advantage without being concerned for the realistic optimism of cooperation. Using the scenarios of the iterated Prisoner's Dilemma game theory (Axelrod, 1984) as an analogy: where the selfish players make choices or take actions freely in uncertain situations within the environment in which they will meet one another again, this theory suggests that the development of a pattern of mutual cooperation with each other tends to provide better benefit than the egoist approach in the long-run. Based on the result of this theory, the competitive approach is less likely to be optimal for the long-term *environmental* sustainability for business survival.

- For our green environment: the self-interest, competitive approach tends to fragment industry into a diversity of specialised enterprises that duplicate tasks among competitors and in which competitive duplication of specific goods or services is generating more waste, such as wasteful consumer products and practices, and natural resources. It also causes global ecological problems, such as the Greenhouse Effect and pollutions, which are affecting human welfare and the eco-system.
- For our society: the competitive, capitalistic approach tends to focus on individual business efficiencies to manage firms and/or business-to-business relationship as a mechanistic system, rather than a real understanding of natural, social power of the complex, dynamic processes of relating and working together for the benefit and well-being of the whole group.

Regarding my viewpoint, I see a viable possibility of continual development of innovative products and cooperation among organisations. I do firmly suggest that in the post-industrial economy, organisations need to adopt a new approach by adjusting their rules of practice; from thinking of self-interested pursuit of gain to thinking relationally and cooperatively for the pursuit of the whole gain. This means businesses need not think about their own self-benefits or empowering themselves individually, but think about relationship, cooperation and reciprocally

sharing actions, visions and resources for the benefits of good innovative products and long-term sustainability. To describe this as a metaphor of an ecological system, organisations should think to be part of, depend on, relate to, and/or cooperate with, one another both directly and indirectly to sustain the balance of the organised whole as a self-sustaining system. It is my hypothesis that a greater prosperity of the global economy and society may emerge from a more harmonious approach, rather than the individual/conflict approach.

As I observe, Smith's theory has appeared to be the *modus operandi* of Drucker's notion and the general organisational practices in the post-industrial economy. As Drucker (1993) suggested in the book, 'Post-Capitalist Society', organisations in the post-industrial society should be continuously self-improving. They should be self-centred, be specialised in their own competence, and discharge only one task. Also, Drucker asserts that organisations should operate in '"parallel" rather than in competition.' Regarding Drucker's notion, I agree that organisations in the post-industrial economy should be continuous self-improving and discrete. However, I argue that they should operate in cooperation and relation rather than in competition, particularly in the development of innovative products.

1.6 STUDY AIMS

The study focuses on the identification of critical factors in the success of collaborative networks between multidisciplinary organisations who develop innovative products. The aims of the study are as follows:

(1) To suggest a network feature in the development of innovative products in the post-industrial economy

(2) To identify critical factors which can contribute to the success of collaborative networks between multidisciplinary organisations in the development of innovative products

(3) To define and evaluate helpful aspects of each critical factor

(4) To generalise the effects of each critical factor

(5) To examine the level of mutuality between the collaborative organisations within each critical factor.

1.7 STUDY SCOPE

The scope of the study comprises two stages:

Stage 1 investigates both existing theoretical and empirical studies of organisation networks which are related to the development of innovative products. Also, it studies the theoretical concept of networks in different areas: system theory, complexity theories, biology and philosophy. Based on the analysis of these studies, Stage 1 suggests the network feature in the development of innovative products in the post-industrial economy.

Stage 2 is the main research focus. The study examines critical factors in the success of collaborative networks of multidisciplinary organisations in the development of innovative products through four network case studies. These cases are selected from two pilot studies in the UK during 1997-2003 (see Section 3.1). They are investigated through the study hypotheses (see Section 3.6) by a network case study methodology. The network case study methodology reflects a need to understand the imperative element of the collaborative networks, which is the structural relations of the collaborating organisations. In particular, the study focuses on the identification of critical factors which underlie the successful connections and relationships within the collaborative product development networks of multidisciplinary organisations at the micro system. Regarding the collaborative network at the micro level, I call it, 'contractual collaborative projects'. As a result, the study will not focus on critical factors

which contribute to the success of innovative products in the market, improvement of the innovative product development process, or the overall organisation strategies that support the effective development of innovative products unless it is part of collaborative situation.

Here are four examples of previous investigations related to the development of innovative products which my study does not focus on:

Firstly, the investigation seeks to identify key factors that contribute to the success of innovative products. It mainly explores outcomes at the product level. For example, Friedel (1994) explored the interplay factors supporting and/or establishing the success of innovative products in market. Some studies aim to describe the different aspects/factors (such as customers benefits, usable and desirable products, and superior product value for the user) improving the value of innovative products which would lead to product success (e.g. Sanders, 1992; Cooper and Press, 1995).

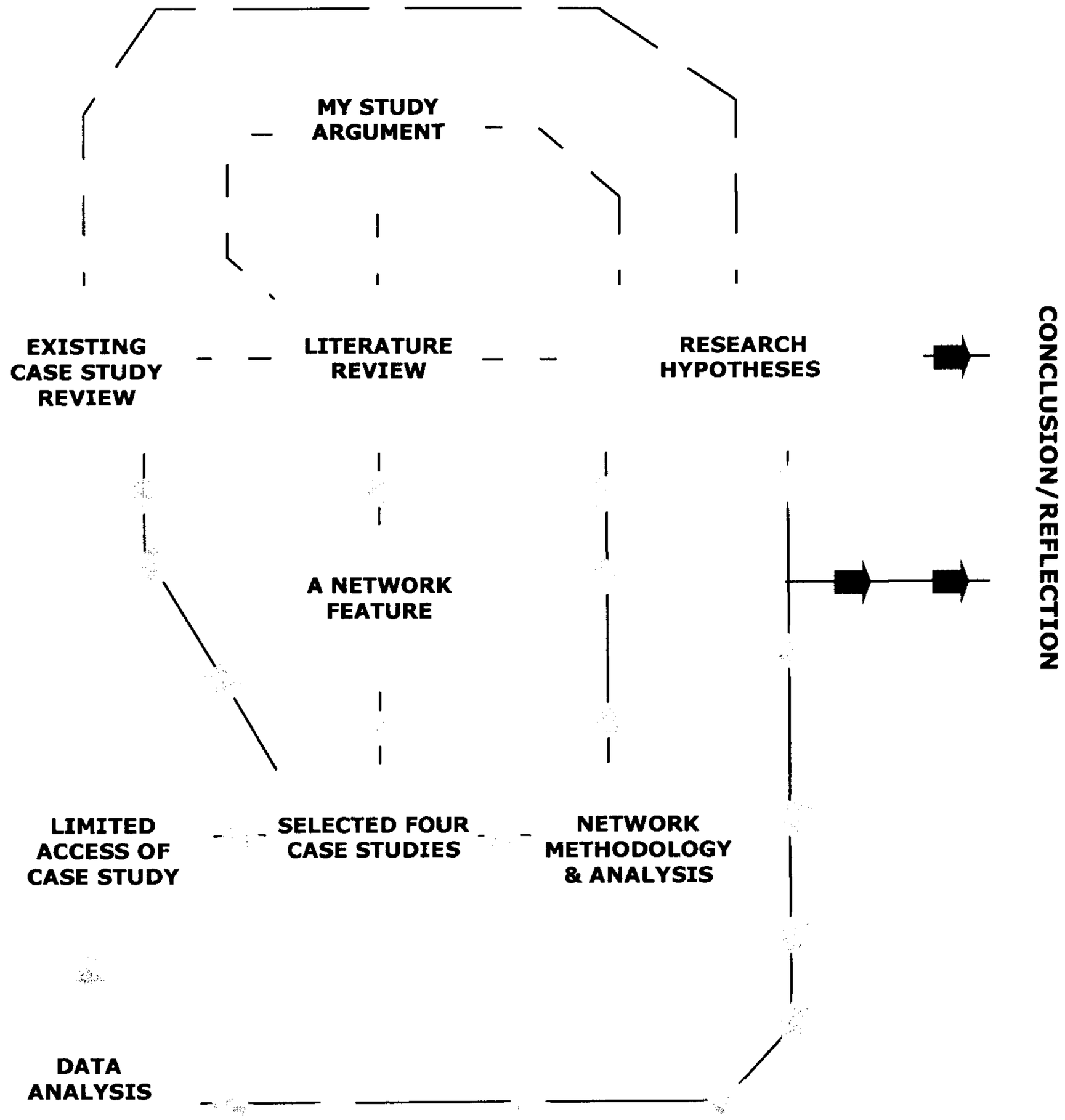
Secondly, the investigation seeks to suggest how to improve new product development. It mainly explores the design and development process. It identifies methods/techniques that improve efficiency of design and development process in order to support the creation and introduction of innovative products (e.g. Cooper, 1983; Robert, 1995; Bruce and Morris, 1998; Ulrich and Eppinger, 2000). For example, Robert (1995) suggested five key strategies during innovative product development process, including (i) searching for new product opportunities, (ii) employing several product assessment methodologies, (iii) developing innovative concepts by identifying critical success factors, (iv) designing an implementation plan, and (v) leveraging those innovative concepts upon the organisation capabilities, and driving forces of business strategy, markets, and products.

Thirdly, the investigation seeks to identify sound management practices which support new product development or innovation within organisations. It mainly explores the overall strategic thinking and planning of organisation management/approach/guidelines which would encourage, improve and/or cultivate the effective organisation for product development (e.g. Carter and Williams, 1957; Langrish et al, 1972; Freeman, 1986; DTI & CBI, 1994; Udall, 1999; Topalian and Hollins, 1999; The Design Council, 2000). For example, Langrish et al (1972) examined 84 technological innovations granted in the Queen's Awards during 1966-1967. They identified seven key factors of successful firms: Top Management support, types of outstanding individuals, clear identification of need, the realisation of the potential usefulness of a discovery, good co-operation, availability of resources and help from government resources. Topalian and Hollins (1999) proposed a management guideline for the new BS 7000: Part 1 for the design dimension of strategic thinking and planning of business futures, including how to assess and harness corporate capabilities to generate market intelligence and to create an appropriate organisation.

Fourthly, the investigation seeks to identify organisation strategies which enhance and benefit the effective product development within organisations. It aims to identify the tactical, beneficial product/design strategies (e.g. Jevnaker, 1998; Tidd et al, 2001). For example, Jevnaker (1998) suggested six aspects of capability in organising design and its management: (i) resourcing capability, (ii) combinative capability, (iii) organisational learning capability, (iv) innovation capability, (v) design-strategic capability and (vi) the capability for securing design-based advantages.

1.8 STUDY STRUCTURE

Diagram 1-1 illustrates the whole study process.



As shown in Diagram 1-1, the structure of the study process is illustrated. The details of each element are:

- ☐ My study argument (Chapter 1)
- ☐ Literature review and defining a network feature (Chapter 2)
- ☐ Research methodology: research hypotheses, network methodology and analysis, limited access of case study and data analysis (Chapter 3)

- ☐ Case study review and the description of four selected case studies (Chapter 3)
- ☐ The investigation of four selected network case studies (Chapter 4-7)
- ☐ Conclusions, reflections and suggestions (Chapter 8)

1.9 INTENDED READERSHIP

The intended readership is 'leaders/owners/CEO of organisations', who have the power to make decisions, direct organisations and change the dynamics of the economic system. The belief of leaders represents that of their organisations. If leaders are willing to change their attitudes and have insights into the logic of co-operation, relation and the holistic view, the whole dynamics of the economic system will be changed. Also, it has been widely recognised that the achievement of great quality, creativity and innovation within organisations is driven by leaders, owners and Top Management. In addition, my study would be a general interest to any designers and readers (e.g. project managers, engineers, marketers and researchers) who are working in the collaborative project between/among multidisciplinary organisations and the multidisciplinary team.

1.10 LIMITATIONS OF STUDY

The main study consists of two main parts: a theoretical study and an empirical study. The limitations emerge when I try to match a theoretical view with my empirical study. This is particularly significant when the theoretical network research methodology is related to the empirical network case study. The limitations occur beyond the controlled ability of my research because of the following reasons:

As I had not directly participated or worked within the collaborating companies, my research position is as a potentially threatening outsider of the subject of the

empirical network case study. As a result, it is very difficult to observe and to get access to all of the information in details.

Secondly, the subject of the empirical network case study is related to both expected and unexpected sensitive issues: the former, the commercial secrecy of innovative product information, and the latter, the business relationships between organisations for future colloaborative works (see details in Section 8.3.4.3).

Thirdly, the subject of the empirical network case study comprises an interwoven combination of complex, dynamic processes of relating and cooperating, such as the dynamics of individual relations and connections within the collaborative teams, the dynamics of interactions between the main points of contact, and the role of each organisation support towards collaborative networks.

As a consequence, these problems cause the following limitations and difficulties: the accessibility of the in-depth investigation of the empirical network case study, the understanding of the whole network dynamics, the accessibility of all networking actors, and the collection of the detailed explanation of innovative products with respect to levels in the product innovation process. Inevitably, these problems affect the data collection during the empirical study and the study findings.

1.11 CHAPTER SUMMARY

Chapter 1 introduces the study thesis which emerges from the interaction between my personal belief, my professional belief, and five essential issues affecting the development of innovative products in the post-industrial economy. Also, Chapter 1 describes the study aims, the study scope, the limitations of the

study, and the summary of the thesis chapters. Moreover, Chapter 1 illustrates the structure of the entire study.

Chapter 2 investigates both existing theoretical and empirical studies of organisation networks related to the development of innovative products. Chapter 2 suggests a network feature which is appropriate to the development of innovative products in the post-industrial economy, that is, collaborative networks among multidisciplinary organisations.

Chapter 3 describes two main pilot studies, particularly focusing on the survey of contractual collaborative networks of multidisciplinary organisations in the development of innovative products within the UK. Chapter 3 also describes the scope of the study research and the research methodology, including network case study methodology and analysis, research protocol and methods, and data analysis. Moreover, Chapter 3 illustrates the entire structure of the empirical network case study research and introduces the four network case studies.

Chapter 4 describes the investigation of Case Study 1: the collaborative network between BAE Systems (BAE) and Nottingham University (NOT) to develop Silicon Gyroscope. All research processes are explained. Critical issues and factors are summarized by both companies' viewpoints. The outcome of Case Study 1 is reflected.

Chapter 5 describes the investigation of Case Study 2: the collaborative network between Remote Controlled Lighting Ltd (RCL) and Cambridge Design Partnership (CDP) to design remote controlled lights. All study processes are explained. Critical issues and factors are summarized by both companies' viewpoints. The outcome of Case Study 2 is reflected.

Chapter 6 describes the investigation of Case Study 3: the collaborative network between a technology-transfer enterprise and a large manufacturing company to design Product X. All study processes are explained. Critical issues and factors are summarized from the view of the technology-transfer enterprise. The outcome of Case Study 3 is reflected.

Chapter 7 describes the investigation of Case Study 4: the collaborative network among three multidisciplinary organisations; a large, manufacturing company, a design consultancy, and a technology-transfer company to design Product Y. All study processes are explained. Critical issues and factors are summarized from the view of the design consultancy. The outcome of Case Study 4 is reflected.

Chapter 8 describes cross-case analyses of the four network case studies. The analysis addresses three main issues: critical factors, the effects of the critical factors and the level of mutuality within each critical factor which contributes to the success of the structural relations between the collaborative organisations. Chapter 8 also contains summary, reflections, suggestions, and contributions of the study thesis.

CHAPTER 2: LITERATURE REVIEW

INTRODUCTION TO CHAPTER 2

In the nature and complex conditions of the post-industrial economy, many observers agree (Roy, 1986; Twiss, 1992; Utterback, 1994; Trott, 1998; Hollins and Hollins, 1999; Perry, 2001) that the development of innovative products is a necessary survival strategy for organisations. To continue to develop innovative products, organisations face three particular problems. First, the development of innovative products is a high risk activity. Secondly, organisations have limited internal resources and experiences. Thirdly, the external conditions that surround the development of innovative products have become more interrelated and of greater complexity. Based on these problems, I argue that organisations should have better insight into their complex external conditions, and how they interact with these conditions. Organisations should also react positively to complex external conditions, making them beneficial to the development of innovative products. My suggestion is, instead of focusing only on the development of innovative products within organisations, organisations should network with each other to do so.

Chapter 2 reviews the theoretical studies related to the concept of networks. It also reviews empirical studies related to organisation networks in the development of innovative products. It suggests collaborative networks of multidisciplinary organisations would be appropriate in the development of innovative products in the post-industrial economy. The details of this chapter are:

Section 2.1 identifies my study focus. This section defines the concept of networks, organisations, and external conditions.

Section 2.2 describes key aspects which drive the existence of organisation networks in the post-industrial economy.

Section 2.3 describes relevant theoretical perspectives related to organisation networks.

Section 2.4 describes four existing models of organisation networks related to the development of innovative products.

Section 2.5 describes the advantages of organisation networks.

Section 2.6 defines three general types of organisation networks: a centre-focused network, a hierarchical network, and a collaborative, decentralised network. It proposes the type of organisation network that is suitable for the development of innovative products in the post-industrial economy.

Section 2.7 describes an appropriate type of collaborative network in the development of innovative products.

Section 2.8 summarises the entire chapter and identifies the main study focus.

2.1 OUTLINING MY STUDY FOCUS

Regarding my suggestion that organisations should network with each other, three key words need to be clarified: network, organisations and external conditions.

2.1.1 NETWORK

In order to understand the concept of networks, I will outline two main concepts which to some extent oppose each other. The first is the idea of individualism in its relation to the market place and economics. The second is a more relational or network model that is clearly based on cluster or social rather than an individual concept. A famous or primary source of an individualistic model is characterised by Smith's economic theory that led to Laissez-faire economics. Smith suggests that the prosperity for all is based on the primary motivations of individuals within society. Rohmann (2000, 225) summarises the idea suggesting that 'the cumulative buying and selling decisions of individuals acting in their own self-interest will lead to the most efficient use of resources, maximize national as well as personal wealth, and enhance social progress.' This model has been dominant particularly amongst right wing economists. Based on this model, individuals are placed at the heart of the agenda

In this study, I am illustrating the other model, the relational model of networking with reference to Buddhism. Buddhism, born over 2500 years ago, teaches us to awaken and comprehend the true nature of existence in our life: life evolving cycle (from birth to death). Based on this core ideology, Buddhism avows the development of positive qualities and the concept of the whole and interconnectedness as a holistic worldview. The positive qualities are taught through the principle of 'Karma', which literally means cause and effect, suggesting that negative action generates negative result and vice versa. The

action may also not generate the result directly and promptly. As a result, the principle of Karma encourages people to eradicate negative qualities and generate good or positive actions in order to create positive consequence in our body, mind and spirit.

Also, Buddhism points to the comprehension of our existence via the concept of the whole and the interconnectedness. Here, I would posit some views of Buddhism that bring out the holistic element. Mahayana Buddhism engenders and expresses an ethic of universal compassion (Reese, 1996) and the selfless ideal of the bodhisattva (see definition in Glossary). Mahayana Buddhism asserts an altruistic position (see Prebish, 2000) and its ethics show that 'the *bhikkhu* [monk] is not a selfish, cowardly individual thinking only of his happiness and salvation, unmindful of whatever happens to the rest of humanity. A true *bhikkhu* is an altruistic, heroic person who considers others' happiness more than his own. He ... will renounce his own nirvana for the sake of others. Buddhism is built upon service of others' (Walpola Rahula cited by Prebish 2000, 45). Taoism and Zen Buddhism also stress the 'interconnectedness of things and the need to allow the world's total flow, rather than individual desires or aims, to determine the parts one follows' Rohmann (2000, 183).

Based on the two very different views, my study will not try to analyse the practicality of them to support this study argument. It would be very difficult to resolve these two polarised logics. On the one hand, Buddhism claims that, regarding our true nature of existence, we are encouraged to generate the positive qualities by understanding universal compassion and the selfless ideal. Smith claims that out of our individual initiatives comes a collective good. However, I would argue that the logic of the network is not necessary an ethical one. This logic is not like the logic of altruism. The study of altruism in Buddhism emphasises the ethical dimension. My study introduces the logic of network

within terms of system analysis and the evolutionary, biological analysis which has few intrinsically ethical dimensions. Academic discourse on networks is a well-established language that sidesteps the polarisation between Buddhist ethics and Smith's ethics.

Turning to the explanation of the concept of the network, I have decided to adopt the philosophy of the dialectical process. Hegel's Theory of Dialectics states that the dialectical process is a process of change, starting from Nothing to Being, and Being to Becoming. The process of change originates from the tensions of the opposites involved in the process itself (Reese, 1996). 'Dialectics' or 'Dialectical Materialism' was further developed by Frederick Engels in his book 'Dialectics of Nature' published in 1879. Engels suggested three universal laws of dialectics:

(1) The law of the transformation of quantity into quality, so that under certain conditions there is a revolutionary leap from a difference in degree to a difference in kind and vice versa

(2) The law of the interpenetration of opposites

(3) The law of the negation of the negation, which does not lead back to the starting point but towards a new synthesis

Based on the dialectical process, the concept of the network incorporates two significant assumptions. Firstly, one opposite part typically participating in a dialectical process is the significant reference point to the other. This means the nature of the relationships a given part has with the other may affect that given part, or vice versa. Secondly, there is a hidden inter-connection between the opposite parts that allows them to interpenetrate to each other in a dialectical process. This means there is a structural relation in which two parts are interacting together. As a consequence of interaction between the opposite parts, there is an emergent property, a new synthesis which cannot be found from the sum of the parts.

To contrast with the individualistic concept, the crucial element within the concept of the network is the relation of the interacting parts. This means the network concept emphasises the relation between the interacting parts, as opposed to the emphasis of a separated part in individualism. In the dialectical process, the relation has a magnetic power to link two opposite parts together so as to establish a dialectical system. The dialectical system becomes an organised whole. Also, the relation mediates the interaction between the opposite parts. Finally, it generates a new part, property or synthesis which cannot be achieved by a separated part, and is an emergent property between the interacting parts.

Therefore, my study defines a network as a system of interacting parts and their relations. The emergence of networks might generate an emergent property which cannot be found from the sum of the interacting parts.

I suggest that a network, by definition, consists of two components: (i) interacting parts and (ii) relations. In living, evolutionary, or social systems, there is the third component, the attributes or the emergent behaviours of their interacting parts.

First, interacting parts are entities that interrelate. In social network analysis and graph theory, the interacting parts are represented as nodes. A node may represent a cell, a living organism, a person, an object or an organisation. In networks, the characteristics of the parts (nodes) can be either similar or diverse. For example, within a customer-supplier network, the attributed quality of the customer has inherent characteristics which are different from the supplier.

Secondly, relations are links between the interacting parts or sets of interconnected parts. In social network analysis and graph theory, relations are visualised as virtual lines which connect the interconnection of the interacting

parts together. Knoke et al (1991) suggested the difference between entities of the interacting parts and relations that, on the one hand, some attributes of a part persist across the various contexts in which the part is interacting (such as quantifiable and discrete qualities). On the other hand, relations are context specific and alter or disappear. For example, in a customer-supplier network, a customer and supplier relationship does not exist outside a business setting, or a supplier-customer relationship vanishes when the contractual project or the business transaction is terminated. Knoke et al (1991) also suggested that a wide variety of relational properties can be measured, such as the strengths of the friendships and the economic exchange between customer-supplier networks.

Thirdly, the attributes or the emergent behaviours or properties of their interacting parts are the relations between relations, and also between the relations and the whole interacting parts. Therefore, the attributes of networks emerge from a whole set of a system of interacting parts, their relations, and the relations of the whole interacting parts. For example, the efficiency of the Toyota's Just-in-time production process is an emergent property of the whole supplier-customer networks.

2.1.2 ORGANISATION

In my study, an organisation is an interacting part within a network. As mentioned in Section 1.3, I have adopted the definition of the organisation from the views of Drucker (1993) and Udall (1999). In brief, an organisation is generally defined as a human group, composed of specialists who work together on a common task. An organisation is always specialised and defined by its task. Each organisation is inherently unique and ontologically distinctive, though defined by specialised tasks. In short, my study defines organisations by their specialised tasks, such as design consultancy, manufacturing organisations, universities, and marketing research organisations, rather than by their size

(depending on a number of employees), internal structure, cultures, strategies, and policies.

2.1.3 EXTERNAL CONDITIONS

In my study, the external conditions are the external environments surrounding organisations. The external environment is an essential element which organisations need to understand, connect to and interact with in the development of innovative products. Morgan (1989, 72) suggests that an environment is a creation made by 'drawing a boundary at some level within a system of relations, thereby separating a particular element from the rest of the system.' Using Morgan, I define the external environment of organisations as the boundary which is beyond their internal relations. My study also embraces the typology of external environments surrounding organisations as defined by Dill (1958, cited by Morgan, 1989, 72). Dill suggests two main types of external environment: (i) the organisation's task environment and (ii) the contextual environment. First, the organisation's task environment includes customers, competitors, suppliers, labour unions, shareholders, government agencies, and other individuals and organisations which an organisation interacts with its everyday functioning. Secondly, the contextual environment includes cultural, social, political, technological, economic, geographic and other forces and shapes which organisations operate. Regarding these two types, the organisation's task environment is my main study focus.

In Conclusion: My study focuses on the concept of the network by its definition as a coherent set of relations among interacting parts. My study argues that the development of innovative products should be produced by establishing a network among organisations and their external environments. Particularly, my study proposes that innovative products should be critically developed by

establishing a network among organisations and their organisation's task environment, called 'organisation networks'.

2.2 THE RISE OF ORGANISATION NETWORKS

Reviewing so far, I have summarised six key aspects that tend to be the main drive of the existence of organisation networks which rise after World War II.

1. There was an organisational transformation from large, hierarchical corporations to decentralisation in the global economy in the last thirty years. The major symptom of this change, as Castells (2001, 166) mentions, is the transition from 'mass production' to 'flexible production', or from 'Fordism' to 'post-Fordism'. Based on Castells, Fordism represents a model of the large corporation structured on the principles of vertical integration, and institutionalised social and technical division of labour. Fordism focuses on 'productivity gains' which are obtained by economies of scale in an assembly-lined-based, mechanised process of production of a standardized product. Castells (2001) mentions that the decline of Fordism is based on two main factors: (i) the demands in global markets become diverse and unpredictable in both quality and quantity, and (ii) the pace of technological change makes obsolete production equipment. This change has also been accelerated by multi-dimensional, interrelated issues, such as social and ecological awareness, diverse culture and global communications, as mentioned in Section 1.4.1.2. Consequently, the mass-production system cannot respond to the requirement of diverse production to suit more demanding and specialised consumers (Kilmister, 2000) and becomes too rigid and costly (Castells, 2001).

2. The diffusion of information technology into our global society. Information technology has emerged different forms of organisational architecture, such as the internally networked organisations, the 'economic web' (Stewart, 1998), i.e. clusters of companies interact and connect through electronic networks, and the virtual organisation –a group of organisations collaborate via electronic networks. Jencks (1996) mentions the phenomenon of change of organisational architecture in the last twenty years that there are the growing number of small, fast-changing companies of less than fifty people who are networked by computer and other media. Recently, it is widely recognised that information technology overcomes barriers in connection, communication, consultation and collaboration across organisations, time zones, and distances.

3. Complexities, instabilities, and rapid changes of external conditions in the post-industrial economy. These external conditions, as detailed Section 1.4.1.2, force the fundamental goal of organisational changes (Castells 2001). Organisations strive to cope with external uncertain environments caused by the fast pace of the economic, institutional, and technological changes by enhancing their flexibility in production, management, marketing, and research and development (Castells 2001).

4. The importance of knowledge and information. Many claim that knowledge and information become the valuable asset in the post-industrial economy (Drucker, 1993; Stewart, 1998; Burton-Jones, 1999; Castells, 2001). Drucker (1993, 38) claims that knowledge has transformed our society and economy since two hundred and fifty years ago, and it is 'the only meaningful resource today.' Particularly, in the post-industrial economy, Drucker suggests that knowledge is 'utility', and is being applied purposefully and systematically to define what new knowledge is needed. Stewart (1998) also asserts that

'intellectual capital' –knowledge, information, intellectual property, and experience are a competitive advantage. Once, it is identified, deployed effectively, and exploited, companies can win. The examples of value of intellectual capital are reflected from the increasing number of collective collaboration within organisations and across organisations (Bennis et al, 1997). Castells (2001, 171) asserts that 'in an economic system where innovation is critical, the organisational ability to increase its sources from all forms of knowledge becomes the foundation of the innovative firm.'

5. The attempt for lean production. Castells (2001, 116) describes the concept of lean production that 'many organisational changes were aimed at redefining labour processes and employment practices ... by the automation of jobs, elimination of tasks, and suppression of managerial layers.' A successful example of lean production is the automotive industry of Japanese Toyota Corporation. Shields (1999) suggested that the fundamental organising concept of the lean production is based on networking enterprise, where the corporation builds mutual-gain processes and relations with its multiple stakeholders: labour-management, assembler-supplier, assembler-distributor-customer, company-shareholder, company-government-society-environment. Based on the analysis of Toyota's lean production, Womack et al (1990) identified key lean production principles (i) perfect first-time quality through quest for zero defects by revealing and solving problems at the ultimate source and achieving high quality and productivity simultaneously by teamwork and worker empowerment; (ii) minimized waste by removing all unnecessary activities by making the most efficient use of scarce resources, such as capital, people and space; (iii) continuous improvement (such as reducing costs, improving quality, increasing productivity) through dynamic process of change, simultaneous and integrated product/process development, rapid cycle time and time-to-market, openness and information

sharing; (iv) flexibility in producing different mixes or great diversity of products quickly, without sacrificing efficiency at low volumes of production, through rapid set-up and manufacturing when needed; (v) long-term relations between suppliers and primary producers (assemblers, system integrators) through collaborative risk-sharing, cost-sharing and information-sharing arrangements. Womack et al (1990) also mentions that lean production provides the following benefits: efficiency of resources use, rapid product development cycle, higher product quality at low cost, high flexibility and long-term relations.

6. The success of cultural economics or community-based economy. The successful examples of community-based economy or business clustering or grouping are operating in all different parts of the world, such as the Silicon Valley, Italian industrial districts and regional science/business park (see more details in Section 2.4.3). It is suggested that business clustering reveal a high level of flexibility to counteract market instability (Perry, 1999) and its abilities to share, disseminate new knowledge, and innovate (Lawson, 2000).

In short, these combined factors are shaping the viable possibility of organisation changes and new form of the economic structure. Focusing on organisation changes, not only do organisations need to change or restructure their systems, production processes and organisational management, but also they definitely alter their product innovation process. Business cooperations and relationships, rather than competition tend to be an optimistic means for the development of innovative products.

2.3 THEORIES OF ORGANISATION NETWORKS

Castells (1997, 470-1) stated that

"networks are appropriate instruments for a capitalist economy based on innovation, globalisation and decentralised concentration; for work, workers, and firms based on flexibility and adaptability; for a culture of endless deconstruction and reconstruction; for a polity geared towards the instant processing of new values and public moods; and for a social organisation aiming at the supersession of space and the annihilation of time."

Reviewing so far, I suggest seven theoretical perspectives that contribute to the different models of existing organisation networks, as shown in Table 2-0:

Table 2-0 illustrates the seven theoretical perspectives in relation to the different models of existing organisation networks

Theoretical perspectives	**Examples of organisation networks**
Transaction cost perspective	Subcontracting manufacturing and production processes in, such as the automotive industry (e.g. Toyota, Honda and BMW)
Virtual organisation perspective	Strategic alliances (e.g. IBM gained access to Apple's user interface, Sony-Ericsson to improve mobile phones)
Social perspective	Italian Industrial Districts in the north central Italy (e.g. Modena, Bologna and Parma), Silicon Valley
Resource dependence perspective	Supplier and customer relationship in the industry (e.g. European Airbus and biotechnology)
Institutional, cultural, ethnic perspective	Japanese horizontal networks (*kigyo shudan*) and vertical networks (*Keiretsu*), overseas Chinese business networks through trusted, personal connections (*guanxi*)
Global perspective	International supplier networks, producer networks, and/or customer networks (e.g. McDonald's and Benetton)
Technological perspective	Cisco Systems, Linux

2.3.1 THE TRANSACTION COST PERSPECTIVE

The transaction cost perspective, introduced by the economist Williamson (1975, 1985) focuses on economising on transaction costs of external market and hierarchy (organisation structure/systems). Regarding the theory of the transaction cost, organisations might consider whether the organisation would prefer to integrate all sources in-house, or link with other external sources depending on cost reductions. Because of cost reduction, the organisation may overlook the value of the creation of products, processes and services. Based on this theory, Perry (1999, 4) suggests that networks are a transitory form of organisation, positioned somewhere between internal management hierarchies and external market mechanisms. They arise in response to the limits of both external market and internal management hierarchies in managing business transactions, where neither offers a satisfactory way of managing them. Perry states that the concept of networks, proposed as a possible solution, replaces the certainty of internal management or legally enforceable contracts by relations based on trust, reputation and mutual dependence. It keeps difficult transactions which require frequent renegotiation and take time to establish outside internal management. It preserves market incentives. It replaces unified internal management by a reliance on active collaboration with other external trading organisations. The network relations between external selected organisations are based on a judgment of relative strengths and weaknesses. Compared with external market transactions, the networks concept is flexible enough to handle difficult transactions. However, Alm and McKelvey (2000) argued that if organisations apply the transaction cost theory to manage innovation, they might choose to have an agreement with external sources with low transaction costs and less flexibility (fixed contract). Or they might decide to invest in one specific external relation, over a long-term period. As a result, the organisations' incentives to link with external sources may decrease and the in-house activities increase. To sum up, the transaction-cost perspective suggests that networks are

viewed as the transitory form of organisations, and happen based on cost reduction incentives.

2.3.2 THE VIRTUAL ORGANISATION PERSPECTIVE

Perry (1999), Burton-Jones (1999) and Powell (1991) have suggested that networks are a new hybrid form of organisation, which exist for a certain period dependent on particular economic necessities. These networks have the potential to replace both internal management hierarchies and the external market, in the essence of virtual organisations. The concept of the virtual organisation is described as; collaborative networks where the relations between the organisations involved provide a fluid organisational structure readily adaptable to the needs of the participating organisations. Collaborative networks among organisations or individuals imply development of more than a series of bilateral arrangements; the system of interactivity between the organisations or individuals may offer an attractive structure in situations where 'market-like' efficiency and flexibility need to be combined with 'firm-like' knowledge integration capabilities (Burton-Jones 1999, 143). Perry (1999) suggests that this perspective was developed from discontent with the transaction cost perspective which views the networks concept as a temporary phenomenon. Regarding this perspective, networks are viewed as 'the coordination through less formal, more egalitarian and cooperative means' (Thompson 1991, 171). Powell (1991) supports this point suggesting: 'networks are associated with specific attributes that provide long-term advantages over internal hierarchies and external markets.' He illustrated the attributes of the economic organisation based on the network in comparison with the external market and internal hierarchy, as shown in Table 2-1. Also, Powell (1991) argues that this networks concept gains three main advantages over market and hierarchy on resource allocation. Firstly, it improves resource use and risk-spreading in areas that are costly and whose success depends on other external organisations' actions. Secondly, it can be

more adaptable to any rapid changes and uncertain demands of external environments than internal organisation management. Also, it allows organisations' flexibility to specialise and to meet changing market opportunities by making and breaking links to other specialised organisations. Finally, it helps to easily access information and skills when required. To sum up, this perspective suggests that this networks concept is a new hybrid form of the economic organisation which is based on the concept of collaborative networks, coordination through less formal, more equal and cooperative means.

Table 2-1 illustrates the comparison of network, market and hierarchy relations

Attributes	Type of economic organisation		
	Market	**Hierarchy**	**Network**
Normative Basis	Contract, Property rights	Employment relationships	Complementary strengths
Means of communication	Prices	Routines	Relational
Means of conflicts	Haggling, legal enforcement	Administrative fiat, supervision	Reciprocity and concern for reputation
Degree of flexibility	High	Low	Medium
Degree of commitment	Low	Medium to high	Medium to high
Tone of relationship	Precision and/or suspicion	Formal, bureaucratic	Open-ended, mutual interest
Preferred association	Independent	Dependent	Interdependent
Elements of other transaction types present	Repeat trade, Contracts as hierarchical documents	Informal organisation, Market-like features (profit centres, transfer prices)	Status hierarchies, Multiple partners, Formal rules

Source: Powell (1991)

2.3.3 THE SOCIAL PERSPECTIVE

The social perspective, developed by sociologists and political scientists (e.g. Granovetter 1985; Grabher 1993) in the West, suggests that all economic transactions are embedded in social relations. They also entail cooperation as well as competition, and implicit relations as well as formal agreements. This perspective posits the principle of clan-to-clan co-operation. Durkhiem (1933, 365, referred by Ouchi 1991, 251) referred to clan-to-clan co-operation as organic solidarity which contrasts to legal contractual relations. The solidarity to

which Durkhiem referred contemplates the union of objectives between individuals which stems from their necessary interdependence. According to Ouchi's (1991) analysis, clan-to-clan cooperation is based on two aspects: normative requirements and informative requirements. First, the normative requirements refer to the basic social agreements that all members of the transactional network must share if the network is to function efficiently, without undue costs of performance auditing and monitoring. The normative requirements of clans consist of reciprocity (all exchange mechanisms), legitimate authority, and common values and beliefs. Secondly, the informative requirements are traditions. Traditions are implicit rather than explicit rules that govern behaviour. Regarding this perspective, Sayer and Walker (1992, 139) suggest that networks are viewed as lying 'over, under and around markets and firms.' In short, this perspective suggests that networks rely on and create some degree of mutual relationships and obligations through social relations.

2.3.4 THE RESOURCE DEPENDENCE PERSPECTIVE

This perspective is one of the organisation theories which give an attention to the interdependence of an organisation with other organisations in its environment. The internal structure of a single organisation is shifted to the nature of the relations between the focal organisation and its exchange partners and competitors. Interdependence would occur because the networking organisations exchange resources, skills and information. This theory emphasises the economic interconnections and political processes. Alm and McKelvey (2000) mention this perspective as the 'Knowledge-based' and/or 'Dynamic Capabilities Theories of Organisations'. Mainly, networks are used as complementary assets of the core organisation (Alm et al, 2000). Teece (1980) argues that the knowledge-based theory emphasises the importance of intangible inputs, such as technological knowledge rather than tangible inputs (costs). Because of the diversification of product areas, organisations may have additional reasons to externalise

knowledge rather than using internal knowledge, based on the transaction cost theory. The issue of cost-reduction is extended and changed into the role of learning and knowledge (Alm et al, 2000). In short, this perspective suggests that organisation networks exist because of the significant role of learning and knowledge by the exchange of resources, skills and information.

2.3.5 THE INSTITUTIONAL, CULTURAL, ETHNIC PERSPECTIVE

The institutional, cultural, ethnic perspective suggests that networks are based on the relationship between culture, institutions, ethnicity and history. Castells (2001) pinpoints the fundamental difference of firms' organisation and behaviour between East Asian economics and the traditional Anglo-Saxon. The Anglo-Saxon pattern is embedded in property rights, individualism, and separation between state and enterprises. The formations of East Asia's business systems are the outcome of the institutional/cultural production from the interplay of culture, history and institutions. East Asia's business systems are based on business networking and/or business groups. Six prevailing, basic types of East Asian organised networks are: Japanese horizontal networks (*kigyo shudan*); Japanese vertical networks (*keiretsu*); Korean hierarchical family business networks (*chaebol*); Chinese family firms (*jiazuqiye*); cross-sectoral, one family-controlled business networks (*Jituanqiye*); and overseas Chinese business networks through trusted, personal connections (*guanxi*). Perry (1999, 56) emphasises that the cultural influences affecting these ethnic business formations, relate to their attitudes to work and achievement as well as practical considerations which have an effect on the motivation and ability to succeed in business.

2.3.6 THE GLOBAL PERSPECTIVE

Castells (2001, 206) suggests that networks are the emergent concept of international relations of organisations, and of subunits of an organisation, and are the basic organisational form of the global economy. Many claim that most

economic activities in leading industries are organized around global networks. Evidence, summarised by Ernst (1994, referred by Castells 2001), suggests five types of inter-firm networks exist in the global economy.

(i) Supplier networks. These are subcontracting arrangements between a client and its suppliers of intermediate production units

(ii) Producer networks. These are all co-production arrangements that enable competing producers to pool their production capacities, financial, and human resources in order to broaden their product portfolios and geographic coverage.

(iii) Customer networks. These are the links of manufacturing companies with distributors, marketing channels, value-added resellers and end-users, either in the major export markets or in domestic markets.

(iv) Standard coalitions. These are initiated by a group of potential global standard setters with the explicit purpose of locking-in as many firms as possible into their propriety product or interface standards.

(v) Technology cooperation networks. These facilitate the acquisition of product design and product technology, enabling joint production and process development.

Also, Castells (2001) surmises that because of global circumstances, such as global competition, uncertainties and the increase of transaction costs, organisations are dissolved into a web of multidirectional networks, externalising their transactions and sharing uncertainties through external international/global networks.

2.3.7 THE TECHNOLOGICAL PERSPECTIVE

The technological perspective suggests that the advent of electronic communications and information technology allows organisations to organise networks via the internet. Castells (2001) illustrated the successful model of the global, networked organisation model, Cisco Systems. Cisco Systems is a firm providing the switchers and routers that direct data around communication

networks in the Internet industry. Based on the expression of Cisco Systems on its business organisation and strategy, this business model has three core assumptions:

"(1) the relationships a company maintains with its key constituencies can be as much of a competitive differentiator as its core products and services; (2) the manner in which a company shared information and systems is a critical element in the strength of its relationships; (3) being connected is no longer adequate: business relationships and the communications that support them must exist in a 'networked' fabric. The global networked business model opens the corporate information infrastructure to all key constituencies, leveraging the network for competitive advantage." (Quoted by Castells, 2001, 180)

This perspective suggests that all economic transactions are embedded in the status quo of global information network infrastructure. Castells (2001) mentions that the Cisco model is a key to its productivity, profitability and competitiveness. This model organises all relationships in/around the Internet, both the external market (its customers, its suppliers, its partners) and internal hierarchies (its internal employees). Many studies suggest that electronic networks via internet are a promising strategy to run businesses in the 21st century.

2.4 EXISTING MODELS OF ORGANISATION NETWORKS

Based on the theories of organisation networks from seven main perspectives, they mainly highlight the importance of organisation networks as relationships between organisations (hierarchies) and other external environments (including external market and other organisations) in different ways. This section aims to demonstrate the existing models of organisation networks, particularly related to

the successful development of new products. The following four existing competing, as well as complementary models of organisation networks are: the subcontracting/supply chain (buyers/customers-suppliers relations); strategic alliances (collaboration, licensing, joint ventures, research consortia); systems of innovation (innovation clusters); and inter-networking the networks (electronic/Internet-based networks –concurrent engineering and Linux).

2.4.1 SUBCONTRACTING/ SUPPLIER-CHAIN RELATIONS

Perry (1999, 143) describes subcontracting between organisations and suppliers as:

"Buyer-supplier relations encompass any exchange of goods and services. Subcontracting refers to a buyer-supplier relation in which goods and services are provided according to specifications customised to the buyer. Subcontracting links vary according to the contribution of each party with respect to procurement, equipment and design. At the minimum, subcontracting may be limited to the hiring of labour services to process raw material provided by the buyer using machinery supplied by the buyer. At the maximum, the subcontractor may have responsibility for material procurement, equipment provision and product design, working either to broad specifications given by the buyer or according to their own designs approved by the buyer. Whatever the type, subcontracting implies a need for communication and negotiation between the parties. All types of buyer-supplier link may involve a continuous relationship, with repeated transactions giving rising to the possibility of an obligational relationship."

Tidd et al (2001, 203) mention that the concept of the subcontracting or outsourcing of non-core activities is theoretically framed in terms of strategic focus, or 'sticking to the knitting'. Perry (1999, 142) observes that 'the decision

to subcontract implies a need or preference to rely on external resources of supply in place of internal capacity. For suppliers, subcontracting can be more than a sales relationship. It may provide insight into the managerial practice of the customer, and access to its technology, providing valuable learning opportunities. For buyers, it potentially provides access to specialised resources and skills, as well as avoiding the risk associated with additions to internal capacity.' Dei Ottati (1996) suggests that subcontracting has a positive impact on organisational development. Perry (1999) cites this in the case of industrial Veneto, Emilia-Romagna and Tuscany; high-tech, R&D and innovation-intensive areas (for example the Silicon Valley, Boston and Britain's M4 corridor); subcontracting nodes formed around Baden-Württemberg and in Southern California; and inner city industrial districts (for example the film industry in Los Angeles). Also, some subcontracting is based on the potential to save costs: suppliers are likely to have lower overheads and variable costs, and may benefit from economies of scale if serving other firms.

Turning to the particular point of radical innovative product development, a number of recent studies encourage organisations to identify and form relationships with lead users/buyers/customers (DTI & CBI, 1994; Hippel et al, 2001) and closer relationships with suppliers (e.g. Womack et al, 1990; Nichiguchi, 1994). Traditionally, the suppliers' relationships have been short-term, contractual arm's-length agreements, focusing on the issue of cost. Suppliers have little input into design and engineering (Tidd et al, 2001). Tidd et al (2001) suggest that the status of subcontractors/suppliers has been improved since they have played such vital roles in the success of Japanese Lean Production in the automotive industry. Suppliers have transformed their overall status from arm's-length transactions into various forms of inter-firm partnership and relational contracting, building on the possibilities of collaboration and trust (Perry, 1999). This sound practice has been applied to organisations'

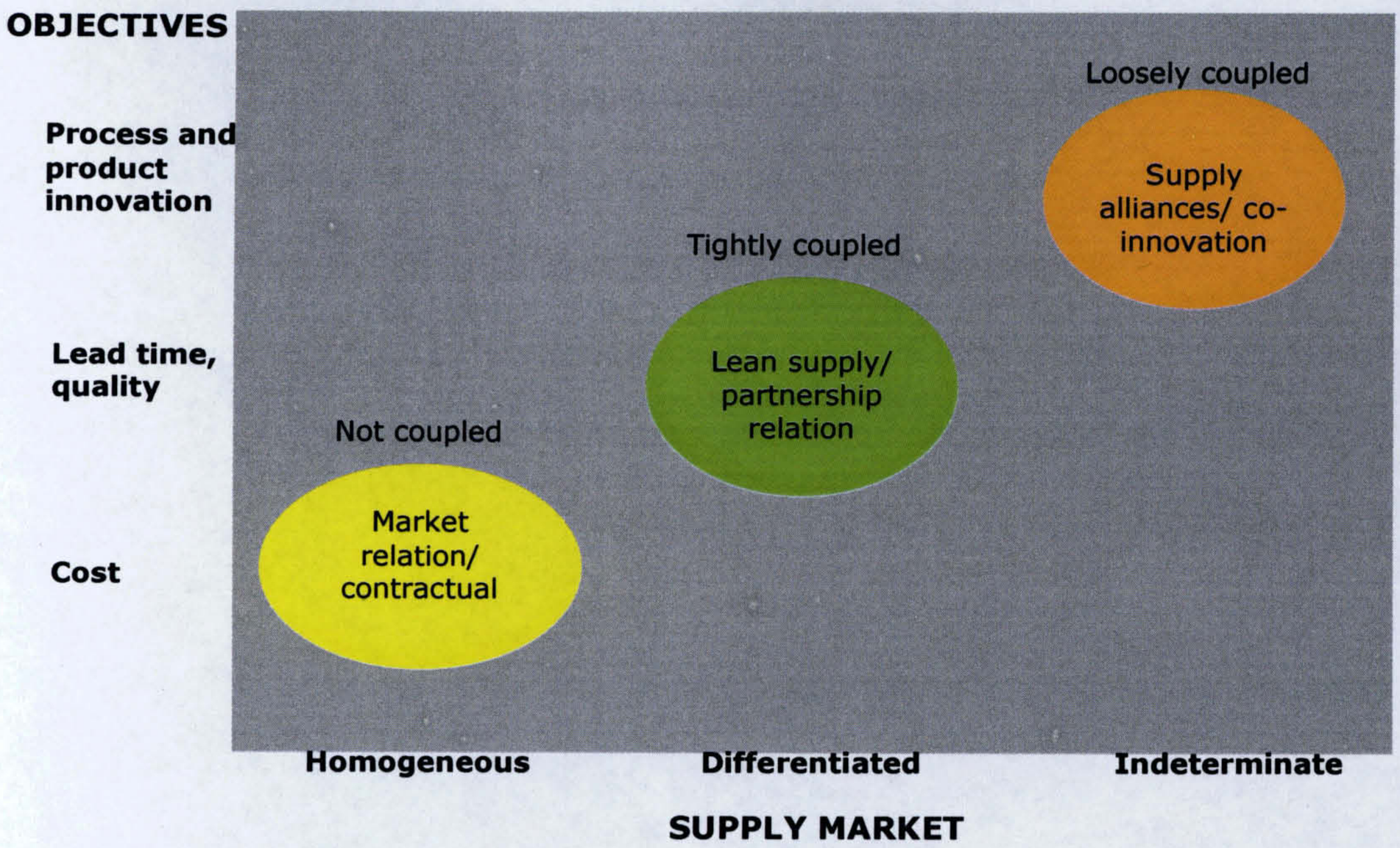
management in a wide range of industries, such as biotechnology, information and communication technology, and the aeronautic industry, and in many countries, such as Germany, UK, USA, Taiwan, and Singapore.

My study suggests that suppliers' relationships can make a significant contribution to the development of innovative products. Tidd et al (2001) propose that closer links between organisations and suppliers could help to reduce the cost of components, through specialisation and sharing information on costs. Womack et al (1990) assert that in the case of Japanese Just-in-time, long-term relationships with suppliers can increase the visibility of cost-performance trade-offs, reduce the time to market, improve product development cycle, and enhance efficiency of resources use.

Tidd et al (2001, 204-5) illustrate a range of potential supplier relationships, as shown in Diagram 2-1. Diagram 2-1 reviews the different types of relationships which are appropriate in different circumstances. It is in essence an argument for carefully segmenting supply needs and suppliers. Tidd et al (2001) suggest that the Diagram comprises two axes. On the vertical axis, objectives range from cost reduction, quality improvement, lead-time reduction through product and process innovation. On the horizontal axis, three types of supply market are identified:

- Homogeneous –all potential suppliers have very similar performance
- Differentiated –suppliers differ greatly and one is clearly superior
- Indeterminate –suppliers differ greatly under different conditions

Diagram 2-1 illustrates a range of potential supplier relationships



Source: Tidd et al 2001 (204)

Tidd et al (2001) suggest three potential supplier relationships which are influenced by organisations' objectives and conditions of supply market. First, in the case of homogenous supply conditions and a primary objective to reduce costs, the ideal arrangement is a traditional market/contractual relationship. In its most recent concept, this might be achieved by means of a business-to-business intranet exchange or club, whereby potential suppliers to a specific customer or sector pool their price and other data, or bid for specific contracts.

Secondly, where the supply market is more differentiated, other types of relationship tend to be more appropriate. In this case, based on the quality and development lead-time benefits, some form of 'lean' relationship or 'partnership' tends to be supported. This has benefited Japanese manufacturers of consumer durables, especially automotives and electronics. Also more recent experiments are in other contexts, such as aerospace in the UK and USA.

Thirdly, it is argued that, in the case of indeterminate supply markets, a lean supply strategy or partnership is likely to be suboptimal or even dysfunctional. Tidd et al (2001) assume that the rigid supply structures of Japanese business groups may offer static efficiencies in terms of quality improvement, reduction in development lead-time, and cost savings, but may undergo dynamic inefficiencies when it comes to developing novel technologies, products and processes. Anderson (1999) suggests that on the one hand, the increase in the global sourcing of technology (the rapid changes of technology outside partnership or lean relationship) has reduced the opportunity that an existing partner will be the most appropriate supplier. This means that sticking to the close system of partnership or lean relationship would hinder organisations adaptability to rapid external changes. On the other hand, the tacit nature, or stickiness, of technological knowledge suggests that a market transaction would be inadequate. Tidd et al (2001, 206) summarise as follows,

"where innovation is the primary objective of the supply relationship, and the supply market is neither homogenous nor clearly differentiated, a temporary, ad hoc relationship with a supplier may be more appropriate. These have some features common to horizontal strategic alliances, in that they are clearly focused, project-based forms of collaboration. In such cases, the relationship is neither market nor partnership, but a hybrid. Loose coupling is appropriate where multi-technology products are characterized by uneven rates of advance in the underlying technologies."

To sum up, the evidence suggests that the collaboration between organisations and subcontractors/suppliers is a suitable form of organisation network in the development of innovative products, rather than contractual arm's-length agreements.

2.4.2 STRATEGIC ALLIANCES

Strategic alliances are another model of organisation network in a micro level. Tidd et al (2001, 211) describe these networks as follows: 'strategic alliances, whether formal and informal, typically take the form of an agreement between two or more firms to co-develop a new technology or product.' Castells (2001, 174) suggests that strategic alliances are very different from the conventional forms of cartels and other 'oligopolistic' agreements because they concern specific times, markets, products and processes, and also particular competitors are included in some strategic alliances.

Jarillo (1988, 32) describes strategic alliances as 'a long-term purposeful arrangement among distinct but related for-profit organisations that allows those firms in them to gain or sustain a competitive advantage when compared to their competitor outside the network.' Similarly, Perry (1999, 27) notes that organisation networks in strategic alliances are held together through relations of owners, investors, or the sharing of membership. Powell and Smith-Doerr (1994, 390) base this model on 'calculatively formed', utilised written contracts so as to control opportunism and be without the 'natural basis of trust'. Strategic alliances are popular in high-technology industries in which soaring cost and risk in R&D exist, access to privileged information has become increasingly difficult, and innovation is the main competitive advantage. The considerable increase in strategic alliances has been mainly attributed to new and technology-intensive industries, such as information technology, biotechnology and new materials (Hagedoorn, 1993; Bruce et al, 1995; Tidd et al, 2001).

Sydow (1992) identifies three distinct features of strategic alliances:

(i) They are an outcome of intentional strategy, although they may also contain some emergent characteristics that reveal a more open relationship.

(ii) Typically, they may also be coordinated by one or more hub organisation. The hub organisation may be permanently engaged in attracting and selecting partners, as well as managing existing relationships.

(iii) Their range of links is widely dispersed among different types of organisations/ businesses/sectors.

Doz and Hamel (1998) identify a range of motives for strategic alliances and suggest that strategies are needed for several reasons:

- ☐ To build critical mass through co-option
- ☐ To reach new markets by leveraging co-specialised resources
- ☐ To gain new competencies through organisational learning

Doz and Hamel (1998) suggest that, to achieve critical mass in a co-option alliance, a company builds temporary alliances with competitors, customers, or companies with complementary products, services, and/or technologies. The company seeks to cluster with relatively weak companies, in particular within the same industry, to challenge a dominant competitor. Where network size or scale is essential, co-option is common, such as in mobile telephony and airlines. Doz and Hamel also mention that, in co-specialised alliances, partners are drawn together, in particular from different sectors, to bring unique competencies to create the opportunities to develop new products, build new businesses, or enter new markets. The co-specialised alliance is common in complex products and services. Moreover, they mention that companies can learn about the skills of other companies by entering alliances. Therefore, alliances could be a way of improving the companies' own processes and routines.

The degree of integration and cooperation within strategic alliances varies encompassing a potentially wide set of organisational relationships, including technology licensing, research consortia, and joint ventures.

LICENSING

In the case of licensing, Tidd et al (2001, 208) point out that

"Licensing offers a firm opportunity to exploit the intellectual property of another firm, normally in return for payment of a fee and royalty based on sales. Typically, a technology license will specify the applications and markets in which technology may be used, and often will require the buyer to give the seller access to any subsequent improvements in the technology."

RESEARCH CONSORTIA

Tidd et al (2001) describe that research consortia comprises a number of organisations committing to working on a relatively well-specified project or purpose, including sharing the cost and risk of research, performing pre-competitive research, pooling scarce expertise and equipment, and the setting of standards. They also show the two distinct forms of research consortia; more centralised shared investment, in a central research facility for a new venture; and less centralised coordinated research taking place located in the different member firms.

JOINT VENTURES

A joint venture is an agreement between two or more firms to co-develop new technology/products for the establishment of new business (Tidd et al, 2001). Tidd et al (2001) suggest two types of joint venture. It may be a new company established by two or more firms, which typically allocates ownership based on shares of stock. Alternatively, it may be two or more firms with a simple contractual basis for collaboration. The critical distinction between these two types of joint venture is that an equity arrangement requires the formation of a separate legal entity.

2.4.3 SYSTEMS OF INNOVATION

The term, 'cluster', 'industrial district', and/or 'innovative milieu', has been used to describe systems of innovation in particular areas or regions, such as the Silicon Valley Cluster in the USA, the north central province of Italy, Baden-Württemberg in the southern region of Germany, and Cambridge and Oxford regions in the UK. Perry (1999, 26) characterises the emergence of such regional clusters/industrial districts in the following way:

"Social networks and family business are a component of spatially embedded networks, but these networks are reinforced by integration through intermediary organisations that share...strong affinity to the particular locality. A combination of influences associated with familial, legislative, political, historical and reputational forces induces a commitment to place, the accumulation of knowledge and a capacity for a high degree of industrial specialisation. Specialisation permits the disaggregation of the production chain, producing extensive collaboration and subcontracting linkages between individual businesses. This gives the abilities to absorb and counteract market instability through the parallel operation of competitive and cooperative business relations. Companies compete while simultaneously learning about changing markets and technologies through informal communications, collaborative projects and common ties to industrial associations and research agencies."

Marshall (1927, referred by Grabher 1993, 21) highlights the benefits deriving from the embeddedness of networks of the clusters or industrial districts within localities with a specific industrial atmosphere: an embedded network allows the organisations to easily exchange ideas, information, and goods; supports the accumulation of skills and innovative capability; and yields the development of a cultural homogeneity allowing cooperation, trust, and consensus among employers, among workers, and between both groups. Successful clusters have

emerged from the region/district/state's technical and institutional infrastructure; the dense networks of social and professional relationships; and the richness, density, and diversity of industrial resources, skills and know-how within geographical proximity. Considerably, interfirm networks, in particular among SMEs, often play an underlying part in maintaining economic prosperity in a region (see Keeble et al, 2000) and firms' innovation performance (see Lawson, 2000; De Propris, 2002). Here are three successful examples: Italian industrial districts, Silicon Valley and Baden-Württenberg.

ITALIAN INDUSTRIAL DISTRICTS

The industrial districts of the north central Italy, such as knitwear in Modena; bicycles, motorcycles and shoes in Bologna; food processing machinery in Parma; and wood working machine tools in Capri have been claimed as an alternative model of organisational network. Powell and Smith-Doerr (1994) suggest that these organisational networks are the exemplars of 'flexible specialisation'. Lazerson (1988) describes each district as comprising small-scale, decentralized production units integrated by business practices, and guided by trust-based governance structures. Each district is loosely linked and has spatially clustered firms (Perry, 1999). The key to the success of industrial districts is generally attributed to their combination of competitive and cooperative forces (Lorenz, 1992), and of craft skills, independence and strong attachment to place (Perry, 1999). Although beyond the scope of this thesis, Perry's work in this area is substantial (Perry, 1999, 81-113).

SILICON VALLEY

Silicon Valley, situated in Santa Clara Valley in California, houses the semiconductor and information technology industry. Saxenian (1994) points out that the rise of this cluster development derives from similar forces to those that produced the prosperity of Italy's industrial districts. Perry (1999) cites the

growth of the semiconductor industry, saying that Silicon Valley was populated by almost 3,000 electronics manufacturing firms, and supported by a variety of prototyping operations, machine shops, material suppliers, and contract manufactures by the mid-1980s. In addition, another 5,000 firms were engaged in providing producer services to the electronics sector, including research laboratories, venture capital, recruitment, market research, design and related support functions. Reflecting on the development of these new enterprises, Rosenberg (2002) observes that their successes are not merely the work of individual entrepreneurs, but have been built up through Silicon Valley's technical and institutional infrastructure, their dense networks of relationships, both social and professional, their working culture, and geographical proximity. These successes are inseparable from a regional environment which has the combination of intense skills and know-how, a regional organisation that fosters new companies and collective learning. Rosenberg also asserts that every developed country in the world today has sought to build its own high technology industry by using California's Silicon Valley as its model. We may think of Cambridge in England, Helsinki in Finland, Tel Aviv in Israel, Bangalore in India, and Hsinchu-Taipei in Taiwan.

BADEN-WÜRTTEMBERG

The south-western German region of Baden-Württemberg, centred around the major industrial city of Stuttgart is one of Germany's strongest industrial regions. The Baden-Württemberg cluster has been built upon a combination of localised networks and core manufacturing organisations. Perry (1999) notes that much of its industrial strength is derived from three sectors: automotive engineering, electronic engineering, and machine building. Large-sized firms dominate employment in automotive and electronic engineering, such as Daimler-Benz, Porsche, Audi, and Sony, around which exist many small and medium-sized enterprises (SMEs). SMEs dominate the machinery industry sector. This Baden-

Württemberg cluster is characterized as a 'hub and spoke network'. In other words, large organisations link and integrate via SMEs as their subcontracting suppliers. These networks have been supported and cultivated by the extensive public sectors –such as regional banks, private businesses, and industrial associations –planned by regional government. Such a richness and density of industrial resources around the region and industry associations have been viewed as a key contribution to the economy's strength. Its success is based on its network architecture, innovation, and cluster development.

2.4.4 TECHNOLOGICAL NETWORKS

Castells (2001, 13) claims that information technology has transformed the capitalist system into a more advanced system:

"The information technology revolution was instrumental in allowing the implementation of a fundamental process of restructuring of the capitalist system from the 1980s onwards. In this process, this technological revolution was itself shaped, in its development and manifestations, by the logic and interests of advanced capitalism, without being reducible to the expression of such interests."

Information technologies, the converging set of technologies in micro-electronics, telecommunications/broadcasting, computing and opto-electronics are integrating the world via global networks of computer connections. Computer-mediated communication creates a wide variety of virtualities, such as virtual communities, virtual enterprises (see Rhodes, 1995; Stewart, 1998), and virtual global society. It has also been claimed that global information and networking systems augment human powers of organisation and integration (Van DijK, 1999; Barabási, 2002). Inevitably, information systems gradually transform the connections, communications, and interactions in our society, economy and culture, and between/among individuals and organisations. Information

technologies have offered new alternatives to existing models of connection, communication, consultation, and interaction between different and remote organisations. Kelly (1995) asserts that the formation of information networks seems to be well adapted to unpredictable patterns of development arising from the creative power of the interaction, and to increasing complexity of such interaction. There are several features and advantages of information technologies in this context:

(i) Because technological networks depend on flexibility, Castells (2001) argues that organisations and institutions can be modified, restructured, or eventually altered by rearranging their components.

(ii) Technological networks allow collaborative acts. The collaborative acts are mainly based on information sharing and collective communication. Barrett (1989, xvi) illustrates the concept of the collaborative act through a hypertext that 'a hypertext is fundamentally a linguistic entity that exists to be manipulated, transformed through a series of collaborative acts, either between just one user and the original database...or among many users performing various operations upon a central core of texts. These operations (drawing new links or annotating existing blocks of text) imply a community of individual users each with a different set of assumptions, a different level of conceptual understanding and different experiences.' Wood (1994, 89) also suggests that 'hypertext methods show particular promise for collaborative work at the early stages of the design process because it can adapt to unforeseen associations between individuals and topics.' Crow (2002) introduces a wide range of collaborative computing technologies and tools which are used to facilitate collaborative acts, such as computer-aided design, groupware software, web-hosted meetings & presentations and chat rooms.

(iii) Because technological networks allow 'real time' communications and 'remote' connections and communications of a similar/different set of relationships, these can be implemented in all kinds of processes and organisations, such as global intranet networks within large corporations and/or global internet networks. Four successful examples of global internet networks are supply-chain relations in Toyota, Benetton, Dell and Cisco Systems. Castells (2001) suggests that without technological networks, it would be too cumbersome to implement connections.

Here are some examples of technological networks (i) which allow different organisations to get connected and (ii) which are implemented to build up organisation networks in the development of innovative products: Linux and Concurrent Engineering/Design.

CONCURRENT ENGINEERING/DESIGN

Concurrent engineering/design, web-enabled tools are predicated on the concept of collaborative computing technology. It aids collaboration between experts from multiple disciplines during the new product development process. It also allows the activities of product developers to work across functions, companies and/or geographical boundaries without the need for physical presence. Collaboration can happen synchronously where all participants view information and/or meet at the same time. Alternatively, it may happen asynchronously, where participants view information and provide feedback at different points in time. Concurrent engineering (CE) may be used to facilitate communication, share information, or obtain input and feedback (see an implementation methodology to adopt CE practices in Jukes et al, 1999). For example, Alibre Design, collaborative 3D Modeling Computer-aided Design (MCAD) allows manufactures and suppliers to develop new products collaboratively. Greco (2003) suggests that this tool

incorporates the web-based, collaborative applications of product data sharing, 3D modeling editing, real-time mark-up, and synchronised voice & text communication tools. Crow (2002) suggests that this technology has speeded up the development process and insures a better product as a result of multi-discipline participations.

LINUX

Linux, the computer operating system has been largely developed by a network of voluntary programmers, referred to as the 'Linux community'. Tidd et al (2001, 218) comment that this may be one of the few true examples of a 'cyber' organisation. Linus Torvalds devised this free operating system to compete with the DOS/Windows monopoly in 1991. It quickly attracted the support of a group of volunteer programmers. A principle of the Linux community is that everybody interested in Linux can subscribe to free software from this community. All members are allowed to copy, distribute and modify this software under the GNU General Public license (more details/copy at www.linux.org, 2001). Tidd et al (2001, 218) suggest that 'the provision of the source code to all potential developers [members] promotes continuous incremental innovation, and the close and sometimes indistinguishable developer and user groups promote concurrent development and debugging.'

In conclusion: The four main models, as summarised in Table 2.2 illustrate the status quo of organisation networks related to the development of new products in the post-industrial economy. From my studies, these models have been promoted as contemporary archetypes which are alternatives in new product development in the post-industrial economy. A wide number of successful industries (such as automotive, textile, fashion, high technology, and biotechnology), large, international organisations (such as IBM, Apple, Volkswagen, Dell, Sony, Philips, and Nokia), and clusters of SMEs in different

regions in Asia, USA and Europe adopt organisation networks as sound standard practices. In my opinion, particularly focusing on innovative product development, they are replacing the economic organisation of in-house empowered resources. The recent studies provide strong evidence which suggests that there are many advantages of organisation networks.

Table 2-2 summarises the existing models of organisation networks related to the development of innovative products

Network types	Linkage characteristics	Issues	Examples
Subcontracting/ supplier-buyer relations	Interaction to enhance role of suppliers and subcontractors	Relational subcontracting	Just-in-time-Toyotism
Strategic alliances	Investment or ownership ties or membership of associations	Collaboration within industry and across industries	Consortia, Licensing and Joint ventures
Clusters	Geographical proximity and shared commitment derived from common values and goals	Regional sustainability, Variation between industrial districts	Silicon Valley, Industrial district in Italy and Baden-Württemberg
Technological networks	Global, real-time based, virtual interactions	Web-enabled tool, Global networked connections, Real-time communications	Linux, Concurrent Engineering/ Design

Source: Applied from Perry (1999)

2.5 ADVANTAGES OF ORGANISATION NETWORKS

Because innovation and flexibility are critical in the post-industrial economy, a number of studies have elaborated the advantages of organisation networks that contribute to three main aspects: the entire networking organisations, individual networking organisations, and innovative product development. First, organisation networks can support the whole networking organisations to generate changes and to cope with complex, uncertain and rapid changes of external environment. Johnston et al (1991) studied the textile industry in the Prato area in the central of Italy. Their findings suggest that small organisations, with co-operative relationships in regional clusters help them to survive in the

following uncertain and complex environment: (i) soaring labour costs (ii) intensifying foreign competition, (iii) demanding greater product variety, (iv) increasing product costs, and (v) falling of product prices in the market. Similarly, Alm & McKelvey (2000) studied the theory of organisation networks and innovation. They suggest that strategic alliances, formed across a group of large organisations can support them to cope with complex, uncertain and rapid changes in the economic environment. Moreover, two studies indicate that organisation networks can improve flexibility and adaptability towards uncertain environments (Grabher, 1993; Perry, 1999). Both argue that co-operative relationships between organisations are more adaptable to environment changes than internalisation of activities within a single organisation. They also suggest that the flexibility and adaptability of organisation networks helps the networking organisations to increase the range of innovative solutions. Castells (1997, 2001) reinforces this point on his study of existing network enterprises. He asserts that networks are adding flexibility to both internal and external operational systems and also provide appropriate models for innovation, globalisation and decentralisation.

Secondly, organisation networks provide a wide range of benefits towards each individual management and business. Trott (1998,) referred to two areas of research from Vyas et al (1995) and Chan et al (1993), where twelve beneficial reasons in entering strategic alliances are identified, as shown in Table 2-3. Perry (1999) also indicates that organisation networks can improve capabilities and resource uses, such as (1) increasing in-house capabilities (production process, technical skills, new technology and marketing information and restructuring internal resources and activities), (2) accessing information and skills, and (3) reducing risks and spreading costs. In addition, Booz, Allen and Hamilton (1999) reveal the result of their research on motivations of strategic alliances from both partners' perspective that the driven motives are: risk sharing, technology

access, product/service extension, scale economies, operational skills, market segment access and marketing skills. Moreover, the UK CBI (2001) analysed the survey of over 350 UK companies which used collaboration in the innovation process and suggests eight benefits of collaboration, in particular order, that (1) created new product/service, (2) increased sales/profits, (3) opened new markets, (4) strengthened knowledge base, (5) new production methods/internal processes, (6) company more outward looking in approach to innovation, (7) increased skills of key staff, and (8) acquired key new staff.

Table 2-3 illustrates reasons for entering strategic alliances in business and management

Reasons	**Examples**
1. Improved access to capital and new business	European Airbus to enable companies to compete Boeing and McDonnell Douglas
2. Greater technical critical mass	Industry alliance formed between US microchips manufactures to compete with Japan
3. Shared risk and liability	GEC-Aisthom, a joint-venture between UK and French power generator manufactures
4. Better relationships with strategic partners	European Airbus
5. Technology transfer benefits	Customer supplier alliances, for example VW, Bosch
6. Reduce R&D costs	GEC and Siemens 60/40 share of telecommunications joint venture GPT
7. Use of distribution skills	Virgin Cola and Tesco
8. Access to market strengths	NMB, Japan and Intel; NMB has access to Intel's Marketing
9. Access to technology	IBM gained access to Apple's user Interface technology
10. Standardisation	Attempt by Sony to get Betamax technology as industry standard
11. By-product utilisation	Glaxo-Wellcome and Matsushita Canon; Fuji
12. Management training	Rover Management general expertise from experiences with Honda

Sources: Vyas et al. (1995); Chan et al (1993)

Thirdly, it can be shown that organisation networks can enhance new product development. Littler (1993) analysed reasons of over 100 UK-based alliances in new product development. Littler indicates the following ten reasons why the UK organisations collaborate with other organisations: (i) in response to key

customer needs, (ii) in response to a market need, (iii) in response to technological change, (iv) in response to competition, (v) in order to reduce the risk levels within R&D, (vi) to broaden the product range, (vii) to reduce R&D costs, (viii) to improve lead time to market, (ix) in response to management initiative, and (x) to be more innovative in product development. Also, Bruce and Cooper (1997, 36-8) referred to two areas of research from Dodgson (1993) and Bruce and Morris (1995) where design outsourcing can solve various internal problems of organisations seeking to generate new products: (i) no in-house design skills, (ii) solving short-term problems, (iii) relieving workloads, (iv) accessing new ideas, (v) accessing specialist expertise, (vi) easier to abort unsuccessful projects, and (vii) cost-effectiveness.

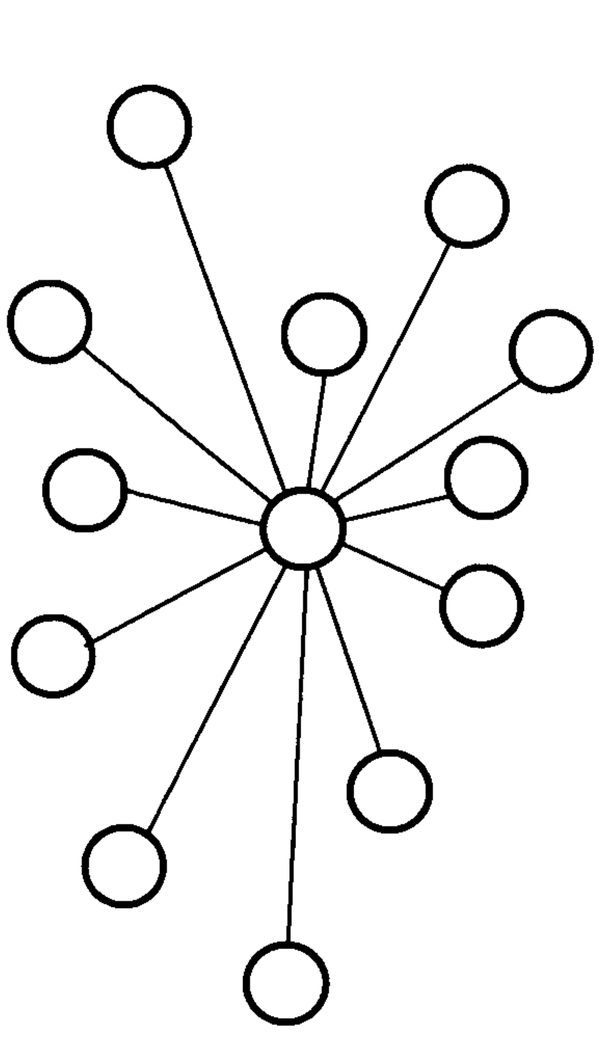
In conclusion: These previous studies indicate three main levels of advantages toward organisation networks that relate to the development of innovative products: the entire organisation networks, each individual organisation and the new product development process. At each level, networks facilitate and sustain innovation and flexibility. For example, in the level of the entire organisation networks, such as the regional cluster, networks help to improve the whole system flexibility by restructuring co-operative relations to be adaptable to complex external environment changes. They also provide more innovative solutions than one would find in a single, vertical organisation, because there are a huge variety of possible relations implicit in organisation networks. Within individual organisations, networks increase flexibility by allowing organisations to access other specialised organisations' knowledge and resources. As I have argued, they enhance the intensity of innovation by sharing risks and costs and increasing in-house capabilities. Finally, in the development of new products, networks can provide a number of benefits: better response to external environment, cost reduction, shorter lead time to market, access to more innovative ideas, and access to greater specialist expertise. I strongly affirm that

organisation networks are important to new product development processes in the post-industrial economy. In particular, the dynamic conditions of this global economy not only shorten the product life-cycle but also affect organisation life, as demonstrated in the recent case of the demise of MG Rover in 2005 that could not compete. Inevitably, organisations need to understand an appropriate strategic network in order to cope with the economic uncertainty and complexity. A key question remains: what is the optimal type of organisation networks for the development of innovative products?

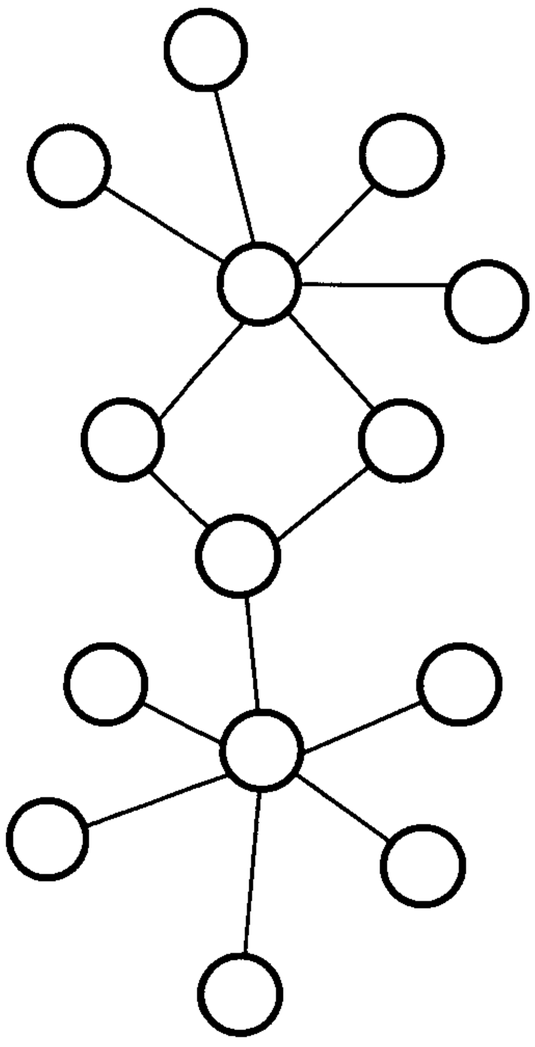
2.6 THREE GENERAL TYPES OF ORGANISATION NETWORKS

One might argue that we can draw a wide variety of networks, or the existing organisations of networks have a wide variety of forms. After analysing the existing models of organisation networks, mentioned in Section 2.4 and previous theoretical studies of networks (Baran, 1964; Cole, 1990; Benassi, 1993; Wit and Weyer, 1998; Burton-Jones 1999), I have classified organisation networks into three main types: centre-focused networks, hierarchical networks, and collaborative, decentralised networks, as shown in Diagram 2-2. These types are distinguished by a system of the relationships among interacting organisations and the organised whole within the network.

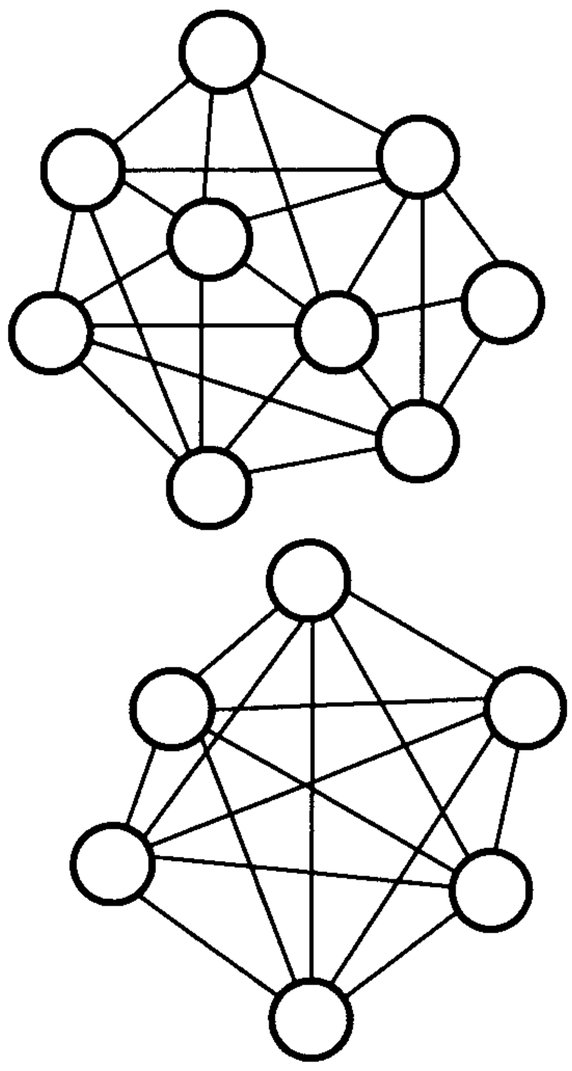
Diagram 2-2 illustrates the overviews of three general types of organisation networks



(i) Centre-focused Networks



(ii) Hierarchical Networks



(iii) Collaborative, decentralised Networks

2.6.1 CENTRE-FOCUSED NETWORKS

What I call the 'centre-focused' network is also referred to by other names, such as 'star' or 'hub and spoke' network (Perry, 1999; Burton-Jones, 1999), 'bilateral collaborative relationships' (Wit and Weyer, 1998), 'centralised' network (Baran, 1964; Cole, 1990), or 'formal network' (Benassi 1993). Perry (1999, 40) suggests that the generic structure of hub and spoke network comprises 'a central coordinating organisation and a series of separate linked satellites connected to each other through the hub'. Burton-Jones (1999, 137) explains its characteristic in relation to the role of the central organisation, i.e. that it may represent the involvement between a single large corporation and its suppliers or distributors. He states that the balance of power in this network is usually asymmetrical and favours the large corporation which controls the network. Benassi (1993) explains this network in terms of the central organisational operations. The central organisation normally uses the standardised procedures and programmes for evaluating the result and it employs routines operations for assessing objectives.

Generally, the centre-focused networks have four main characteristics. First, a density of authority is at the centre. There is little authority is exercised outside a key or central group. The network is controlled by a hub or central organisation. The central organisation manages and organises the whole network. Secondly, despite having mutual convergence between the central organisation and more remote organisations, the central organisation links with other organisations by servicing its internal needs, complementary resources, and goal achievement. Other organisations are subcontractors or arm-lengths of the central organisation. Thirdly, the central organisation controls other organisations by using formal modes of connection, such as short-term and long-term contract or legal agreement. Finally, communication and cooperation operate via the central organisation. This means that collaboration among other organisations within the network is manipulated by the central organisation. The examples of this network type are manufacturing sub-contractors in automotive industry.

2.6.2 HIERARCHICAL NETWORKS

What I call the 'hierarchical' network is also referred to by other names, such as 'decentralised' (Baran, 1964) or 'chain' (Cole, 1990). Baran (1964) describes it as the mixture of two general components: 'centralised' (or star) and 'distributed' (or grid or mesh). Baran suggests it in terms of communication networks, that the decentralised network shows the hierarchical structure of a set of stars connected in the form of a larger star with an additional link forming a loop. This network does not rely on a single or central hub. Cole (1990) also describes it that this network is basically hierarchical and not decentralised. The hierarchical network is one in which communication and information tend to flow through a chain of interaction. A leading organisation or a group of leading organisations communicate policies, plans, information, instructions through chain of interaction, normally downwards. Peripheral organisations communicate

information, such as ideas, suggestions and comments, back along the chain. In another word, the hierarchical network tends to be dominated by what flows by means of the organisation chain. The examples of this network type are vertically integrated business groups in Japan (*keiretsu*) and Korea (*chaebol*).

I would claim that the main characteristics of the centre-focused and hierarchical networks are analogous to the idea of mechanistic systems. Burns and Stalker (1961) describe that mechanistic (bureaucratic) organisations tend to adopt vertical lines of communication and interaction. The operations and working behaviour also tend to be dominated by superiors. The mechanistic organisations tend to control their power at a core team of management. Von Bertalanffy (1969) also mentions this idea that the whole system is reduced into the mechanisms of a machine viewed as formal combinations of working parts by ignoring the concept of informal organisations or without understanding the organic whole. Von Bertalanffy gives an example of this idea framed in the theory of formal organisations that organisation structure; such as in an army, bureaucracy, and business enterprise, is strategically instituted. Within the theory of formal organisations, organisations are viewed as a system, which is a combination of working parts and mutually dependent variables. Organisations are arranged based on the concept of making an organisational system as reliable as possible. As a consequence, the system (as organisations) needs to be mechanised, conformed, controlled, and standardised. A working part becomes a cogwheel of the whole mechanistic system. It needs to perform its particular, specialised function which is related to others to make the whole system work properly. The system is controlled by certain goals and rules. It is suggested that the mechanistic system, applied to organisation management is useful when this system is operated in a stable environment (Burns and Stalker, 1961; Flood and Jackson, 1991), and performing straightforward and repetitive tasks (Flood and

Jackson, 1991). Based on Flood and Jackson's study, the drawbacks of this system are pointed out:

(i) it reduces the system adaptabilities

(ii) it fails to recognise its interaction with external environment

(iii) it fails to acknowledge the importance of its parts

(iv) if fails to acknowledge the interdependence of its parts

(v) it is static, not dynamic

(vi) it is focused on controlling the system which may encourage inefficiency

(vii) it is analytical and predictive

What emerges from Flood and Jackson's work is that, generally speaking, a mechanistic model is suitable for the efficient production in a stable environment. However, it is not suitable for the development of innovative products in a complex environment. There are a number of weaknesses. For example, it fails to acknowledge the synergistic interdependence of its parts. It also provides no inherent capacity for adaptability. Moreover, it is static and rigid, not dynamic. Furthermore, it is not intelligent and responsive to changing environment.

A number of recent studies find similar weaknesses and suggest that many existing systems of organisation networks are still organised under the mechanistic systems. Centre-focused and hierarchical networks are not very particularly suitable for the continuous development of innovative products in a complex environment. For instance, Perry (1999) argues that supplier-buyer relations, especially Japan's *keiretsu* (the model of Toyotism) have become barriers to regaining economic dynamism in the 1990s because of the process and effectiveness of obligational contracting ties that provide a mechanism for mutual improvement. However, these ties become a problem when Japan's *keiretsu* needs to operate in an open international economy because these ties are set up to protect, rather than encourage outside, overseas partnerships, such

as investors. Castells (2001, 170) argues that 'Toyotism is a management system designed to reduce uncertainty rather than to encourage adaptability. The flexibility is in the process, not in the product.' Tetsuro and Steven (1994) suggested that Toyotism could be considered as an extension of vertical hierarchical organisation, 'keeping the same principles of mass production, yet organising the production process on the basis of human initiative and feedback capacity to eliminate waste (of time, work, and resources) while maintaining the characteristics of output close to the business plan' (referred by Castells 2001, 170).

Returning to the concept of clusters in particular industrial district areas, it is claimed that industrial districts, such as Northern Italy are not capable of continuous radical innovation. Perry (1999) says that this is because Northern Italy's industrial districts have been captive within their local long-established specialisations and collective market identity. Their market segment depends on their reputation and quality, which protects industrial districts to continuously produce radical innovative products, preserves industry skills, and allows local organisations to remain as specialists.

As I have shown, it is widely claimed that the paradigm of information technology is based on flexibility. Organisations and processes can be modified, and even fundamentally altered, by rearranging their mechanism. However, technological networks may also be closed and mechanistic. It partly depends on who manages them. Castells (2001, 71) argues that:

"we must stop short of a value judgement attached to this technological feature. This is because flexibility could be a liberating force, but also a repressive tendency if the rewriters of rules are always the powers that be."

Burton-Jones (1999, 144) argues that much networking is yet to become well managed, pointing out that, even though the internet offers an obvious medium for developing business networking, to date, '...most of the electronic communities which have emerged have been limited to informal knowledge sharing, rather than knowledge trading and the development of cohesive business communities.'

In short, in complex environment, centre-focused and hierarchical networks tend to be not sufficiently adaptable. They tend to be static and unresponsive. They tend to be appropriate for stable environment. As a result, their systematic structure is very difficult to change. Based on each above two models of organisation networks, it creates a locked-in condition (such as long-established specialisations in local areas, strong contracting ties, and collective marketing identity) which discourages the system to reproduce itself, or to sustain the development of innovative products. To sum up, it is likely to be more suitable for the continuous improvement of products or the management of specialised production.

2.6.3 COLLABORATIVE, DECENTRALISED NETWORKS

What I like to call 'collaborative, decentralised network' is also referred to as 'loose multilateral webs' (Wit and Weyer, 1998), business networking (Burton-Jones, 1999), 'informal network' (Benassi, 1993), 'temporary team' (Bryne et al, 1993), 'teamnets' (Biemans, 1995), or 'distributed' network (Baran, 1964). The collaborative, decentralised network is one in which communication, information, power, authority and benefits are widely diffused throughout every organisation within the network. This network is non-hierarchical and non-centralised. It tends to have lateral communication and is organic in operation. Benassi (1993) outlines the most obvious characteristics of a collaborative, decentralised network in saying that it does not have single or central organisation. Collaborative

partners have mutual agreements that encourage adaptation, decisions, and selections. They also sustain an autonomous structure, and a virtual or emergent organisation. Further, information and communication are normally open to all partners. Burton-Jones (1999) shows how this network type tends to be organised on a communal basis, rather than controlled by one participant. The nature of relationships between the parties is broadly symmetrical in terms of power. The networks are typically designed to facilitate 'many to many' mode of transaction so that all parties can communicate with each other. Bryne et al's study characterises these as 'a temporary team' which my study uses to be a representative of the right form of the collaborative, decentralised networks. A temporary team is 'a temporary network of independent companies –suppliers, customers, even erstwhile rivals... share skills, costs and access to one another's markets ... this new evolving, corporate model will be fluid and flexible –a group of collaborators that quickly unite to exploit a specific opportunity. Once the opportunity is met, the venture will, more often than not, disband' (Bryne et al, 1993). The examples of the collaborative, decentralised networks incorporate: strategic alliances of research and development of new technology, consortia, and industrial networks emerged from Silicon Valley and regional high technology clusters.

Focusing on the characteristics of collaborative, decentralised networks, they are analogous to the idea of living systems, as opposed to mechanistic systems. A number of studies in different areas, such as ecology (Capra 1982, 2002), biology (Bergson, 1911), physics (Gleick, 1988; Waldrop 1992), social systems (Luhmann, 1995, Capra, 2002), culture (Capra, 1981), cognitive theories from neurology and ecology (Maturana and Varela, 1980, 1992), economics (Waldrop, 1992) reveal an emergent system which we know as living systems (Capra, 1982, 2002), self-reproductive system (Maturana and Varela, 1980), complex systems (Waldrop 1992), nonlinear dynamics (Gleick 1988), or self-organising systems

(Pask and Von Forester, 1960; Pask, 1961). These systems are complex and unpredictable partly because they depend on the interactions between systems and systems, and between systems and their environment. These are emergent systems. The emergence of these systems depends on the interactions and connections of the whole. Waldrop (1992, 11) described these emergent systems that:

"...a great many independent agents are interacting with each other in a great many ways. ...the very richness of these interactions allows the system as a whole to undergo 'spontaneous self-organization'...In every case, groups of agents seeking mutual accommodation and self-consistency somehow manage to transcend themselves, acquiring collective properties such as life, thought, and purpose that they might never have possessed individually."

Although the nature of these systems is complex, it is claimed that their emergent attributes are suitable for the conditions of a chaotic environment: upheaval, uncertainty, and rapid change. The following attributes are:

Firstly, these systems are able to survive and sustain themselves in changing environment (Bergson, 1911; Capra, 2002). Waldrop (1992, 12) describes that '...these complex systems have somehow acquired the ability to bring order and chaos into a special kind of balance. This balance point –often called "the edge of chaos" –is were the components of a system never quite lock into place, and yet never quite dissolve into turbulence, either. The edge of chaos is where life has enough stability to sustain itself and enough creativity to deserve the name of life.' Also, it is suggested that these systems attempt to ensure the survival of the whole system rather than the achievement of its particular parts/agents/goals (Beckford 1998).

Secondly, these systems are open, responsive and adaptive to their changing environments. Waldrop (1992, 11-2) says:

"...these complex, self-organizing systems are adaptive... They actively try to turn whatever happens to their advantage. Thus, the human brain constantly organizes and reorganizes its billions of neural connections so as to learn from experience (sometimes, anyway). ...every one of these complex, self-organizing, adaptive systems possesses a kind of dynamism... Complex systems are more spontaneous, more disorderly, more alive... The edge of chaos is the constantly shifting battle zone between stagnation and anarchy, the one place where a complex system can be spontaneous, adaptive, and alive."

Also, Waldrop suggests these attributes, 'open, responsive, spontaneous and adaptive' that they differentiate non-living (mechanistic) systems from living systems.

Thirdly, these systems are intelligent. Maturana and Valera (cited by Capra 2002, 31) characterised the intelligence of these systems by their ability to learn. Their learning occurs through the process of building up what they call 'structural coupling' with other living systems or their environments. Maturana and Varela (1987, 75) defines Structural Coupling as the interaction between two units within the environment consists of reciprocal perturbation. Capra (2002, 31) mentions that 'as a living organism [system] responds to environmental influences with [its] structural changes, these changes will in turn alter its future behaviour.' He suggests that these changes, through a structurally coupled system, are a learning system. He also indicates that the key characteristics of all living systems are able to consequently continuing adaptation, learning and development, through continual structural changes in response to the environment.

Fourthly, these systems are synergistic. They create the synergistic value, called 'emergent properties' or 'synergy'. This value is a result from the total sum of a system which cannot be found in the sum of the separated parts. Waldrop (1992, 12) describes:

"...all these complex systems have somehow acquired the ability to bring order and chaos into a special kind of balance. This balance point –often called the edge of chaos... The edge of chaos is where new ideas and innovative genotypes are forever nibbling away at the edges of the status quo, and where even the most entrenched old guard will eventually be overthrown."

Comparing living systems with mechanistic systems, as shown in Table 2-4, these living systems might prove to be an inspiration for the development of innovative products in complex environment.

Table 2-4 illustrates the comparison of system attributes between general mechanistic systems and living systems.

System Attributes	Mechanistic Systems	Living Systems
System boundary	Close	Open
System construction	Predictable, controllable, mechanical, through mediator	Organic, random, partly unpredictable, spontaneous
Interaction with system environment	Static	Intelligent and responsive
System structure	Rigid, linear	Flexible, non-linear
System innovation	Obsolete (not reproduce itself)	Generate itself (the concept of continuous innovation)
System properties	Predictive, analytical, specified	Emergent, synergistic, diverse
The performance of system	Efficient performance in specified environment	Adaptive to changing environment

Sources: Loosely derived from Von Bertalanffy (1969), Flood and Jackson (1991), Waldrop (1992), and Capra (2002).

The existing organisation networks review the viable quality of collaborative networks in the development of innovative products. For example, in the rapid development of innovative products in high-technology industries, such as information and telecommunications technology, the underlying success is based on cooperation and relation between firms, and between firms and other

institutions within the industry. Castells (2001) suggests that the structure of rapid change of innovation within high-technology industries in the world is resulted from an increasingly complex web of alliances, agreements, and joint ventures in which most large corporations in particular are interrelated. Also, if scrutinising region clusters, such as Cambridge Science Park in UK (www.cambridge-science-park.com, 2001), high-technology clusters in Europe, such as Cambridge and Oxford (UK), Grenoble (France), and Munich (Germany) (see keeble et al, 2000), and Silicon Valley in California (USA), these clusters attempt to promote open systems which build up a suitable environment in encouraging interaction and collaboration among organisations within the clusters. Keeble et al (2000) suggest that '...the impact of the early 1990s European wide recession, most of [regional high technology] clusters [in Europe] appear to have been growing rapidly in the 1990s, through processes such as new firm spin-off and endogenous expansion ... they are characterised by new forms of production organisation, based on high levels of inter-firm collaboration and cooperation, strong links with local knowledge centres such as universities, and the development of a regionally-embedded capacity for "collective learning"...'. These suggest that collaborative, decentralised networks, collaborative joint ventures formed by companies are likely increasing the pace and intensity of radical product innovation.

In Conclusion: Three general types of organisation networks have been identified by a system of the relationships among interacting organisations and their organised whole. The centre-focused and hierarchical networks are suggested as a suitable form for efficient, specialised, flexible production and incremental product innovation. It would be efficient if operating in a stable environment. The collaborative, decentralised network is suggested as an appropriate type for radical product innovation, particularly in complex environment. I would argue that the difference between the centre-focused and

hierarchical networks and the collaborative, decentralised network is qualitative. The level of complexity and organic relationships within the collaborative, decentralised network tend to have smart, creative awareness within that complexity and organic relations. As a result, collaborative, decentralised networks are likely to be an appropriate model in the development of innovative products in complex conditions of the post-industrial economy. The next question is what type of collaborative, decentralised networks is suitable for the development of innovative products?

2.7 COLLABORATIVE NETWORKS OF INNOVATIVE PRODUCTS

Marzano (1998, 16), Director of Philips Future Design, mentions that

"Design in a world of high complexity should no longer be a case of clever individuals or teams creating products in splendid isolation, but of multidisciplinary organisations or networks creating 'relevant qualities' and 'cultural spheres'. If we're to make the quantum leap from the limited materialistic and quantitative market to the unlimited more spiritual and qualitative market, then we must provide the design worthy of it."

This suggestion depicts the role of design as the heart of business activities. As a result, Marzano emphasises that design organisations use to combat such a web of high complexity and to develop innovative products for a more spiritual and qualitative market than the existing one must be mutually supporting between multidisciplinary organisations. I agree with this claim and argue that it is a vital requirement for all types of disciplinary organisations embedded in the post-industrial economy which are involved in, relate to, or affect the activities of

innovative product development to mutually support and collaborate together as collaborative networks. Both theories and empirical evidence confirm my argument.

2.7.1 THEORIES RELATED TO CO-CREATION

A number of theories support my argument and illustrate how innovation can emerge from the interactions of players within heterogeneous networks. The following perspectives are:

First, Hegel, the German philosopher in the 19th century viewed historical change as a dialectical process. The dialectical process originated from the tensions of the opposites or two contradictory forces (interactions between thesis and antithesis) which are resolved in a higher solution, called 'synthesis'. Synthesis is the emergence of a condition that subsumes and supersedes the original (the interaction between thesis and antithesis). The dialectical process was not a circular process of change, it would continuously evolve and grow, empowered by its own partiality (Reese, 1996; Rohmann, 2000). This theory suggests a philosophy of change.

Secondly, Marx's views may be helpful, although it is wise to consider that he was a critic and philosopher of the 19th century, rather than a business manager. Nevertheless, his perspectives have proved to be an enduring, if somewhat hidden influence on many aspects of modern society. Marx embraced Hegel's dialectical process within his materialist conception of history. The dominant ideology of Marxism is influenced by philosophical schools of thought in materialism and dialectics. According to Marxist philosophy, changes are based on dialectical process of pure matter (materialism), freed from traditional theological influences. In Marx's theory of political economy in the book, Capital, institutional, economic or social change is based on pure matter of actual human

activity in the fundamental level, labour or blue-collars, instead of capitalist activity. Marx (1859) argued that 'it is not the consciousness of men that determines their existence, but their social existence that determines their consciousness.' According to Marx, the thought of social development is fundamentally based more on the movements and communal actions, rather than the efforts of individuals (Bookchin, 1974). In short, Marx's theory suggests that actual collective human acting and interacting creates, reproduces, destroys or changes institutions: the power of shared human action leads to innovation.

Thirdly, the French Philosopher, Bergson propounds a theory of natural evolution which is illuminated from the idea of co-creation driven by a divine 'creative urge', rather than natural selection (Rohmann, 2000). Bergson (1911, 53) asserts:

"We said of life that, from its origin, it is the continuation of one and the same impetus, divided into divergent lines of evolution. Something has grown, something has developed by a series of additions which have been so many creations. This very development has brought about a dissociation of tendencies which were unable to grow beyond a certain point without becoming mutually incompatible... Evolution has actually taken place through millions of individuals, on divergent lines, each ending at a crossing from which new paths radiate, and so on indefinitely."

Bergson's idea illustrates the philosophical and evolutionary thought that natural evolution cannot grow beyond a certain point without creatively mutual interactions among different organisms.

Fourthly, Papanek (1971, 323) suggests a perspective for innovation by illustrating that 'acceleration, change and the acceleration of change itself arise

from the meeting of structures or systems along their edges.' Particularly, he referred to Frederick J Teggart, a historian, who described this illustration:

"The great advances of mankind have been due, not to the mere aggregation, assemblage, or acquisition of disparate ideas, but to the emergence of a certain type of mental activity which is set up by the opposition of different idea systems."

Both Papanek and Teggart's ideas suggest that change derives from the interactions of two different systems and are analogous to Hegel's dialectical process.

Fifthly, Checkland and Scholes (1990) embraced the idea of holistic thinking and introduce the concept of 'Soft Systems Methodology'. They argue that in the management of complex situations related to human affairs, the identification of the objectives is problematic. They suggest how to identify the objectives of problems by mapping relations in a way that helps participants to understand an entire system. Checkland et al (1990, 5) suggest that in the creation of any concepts, all involved participants should be included in a very holistic way, for example someone who benefits in concept, someone who initiates concept, someone who takes action on concept, someone who is impacted by concept, someone who could stop concept. They assert that the main reason of this holistic approach is to allow all requisite participants who have different experience and background to share their intentions. This method illustrates the significance of the holistic view and the power of shared experience among different interest groups in order to solve complex problems.

Finally, Law (1999) introduced Actor-Network Theory in the mid-1980s and referred to the group of actor-network theorists who claim that knowledge is a

social product that is an effect of network of heterogeneous materials. The group of actor-network theorists also state that all of social life -computer systems, organisations and technologies are ordered with networks of heterogeneous materials which are composed not only people, but also any material –machines, texts, money and architectures. Law mentions that most of new knowledge, products, processes and services are the appearance of unity and the disappearance of network.

In Conclusion: these theories confirm that innovation emerges from the networks of heterogeneity, where there are the interactions of two different forces, such as in Hegel's dialectical process, or the interactions of multi forces, such as in the actor-network theory and Marxism. Philosophers and theorists in history, social politics, ecology, design studies and knowledge have recognised the power of interactions between heterogeneous networks to bring out the evolution and/or revolution of objects, organisations and systems. I trust that heterogeneous collaborative networks are an appropriate basis for the best model of innovation.

2.7.2 EMPIRICAL STUDY

In my empirical studies of collaborative networks in the development of innovative products, I reflect my hypotheses based upon the above examples of innovation that emerges from heterogeneous collaborative networks. I believe that collaborative networks of heterogeneous or multidisciplinary organisations are an appropriate model. The following empirical studies of researchers, academics and professional practitioners elaborate the significance of heterogeneous collaborative networks.

2.7.2.1 DESIGN METHODS MOVEMENT

In the last quarter of the 20th century, design researchers sought to study the principles, practices and procedures of design in a systemic sense. Design methodologists, such as Jones (1980), Cross (1985), Archer (1985), Mitchell (1993) suggested that we needed new design methods and principles.

Jones (1980) argued the traditional design methods of individual creativeness – craft methods (concerning only the product as the centre of the design task) and design-by-drawing could no longer support the increasing complexity of design problems. Jones (1980, 6) mentions that 'the objectives of design become less concerned with the product itself and more concerned with the changes that manufacturers, distributors, users and society as a whole, are expected to make in order to adapt to, and to benefit from, the new design.' Also, many suggested that within the post-industrial culture, design should not concern just the product as a self-contained object by ignoring the existing related conditions surrounding it. Arguably, designing should consider the design of the whole system: the end-product is a part of the whole system (Archer, 1985; Cross, 1985). Design also must include consideration of 'the total process of design', every stage up to, and including the eventual product disposal, such as product maintenance, product services, the effect of the product on the environment, and redesigns (Hollins and Hollins, 1995; Hollins, 1999b).

Jones (1980) proposes new design methods, such as 'collaborative designing' which allows everyone, related to changes of new product, contributing their best images and practices in order to portray new design solution. Also, he suggests the need for 'multi-professional' designers who made intuitive decisions based upon prior knowledge and experience. He urges the need to find new methods (1) that reach across the physical and social levels of designing, (2) that are suited to collaboration: the sharing of responsibilities between users and experts, and (3)

that are suited to imaginatively designing in a collective process. Archer (1985) also suggests that designing should be involved with a wide range of specialists, such as those involved in ergonomics, cybernetics and management science. Moreover, Mitchell (1993) studied design methods and recognised the need to insert collaboration within the design process. Mitchell argues that design methods should permit many people (multidiscipline) to collaborate during design process, instead of the reliance on a single person's (a designer) ability to know and effectively synthesise all relevant information to a design task. A study in Eco-design also supports this argument (Van Der Ryn et al, 1996). In short, the study of the design methods movement suggests that to design, a wide range of specialists should be involved during design process and new design methods should allow a holistic approach.

2.7.2.2 NEW PRODUCT DEVELOPMENT MOVEMENT

Based on the study of product innovation management, including new product development and innovation management, particularly focusing on the internal organisation level, these studies involving the management of product innovation successes and/or failures are analysed. They include the management of (i) new product development (Rothwell, 1972; Cooper, 1979; Cooper, 1983; Holland et al, 2000), (ii) technological innovation (Carter and Williams, 1957; Langrish et al, 1972; Langrish, 1985; Freeman, 1986) and (iii) innovation (Trott, 1998; Brunel University, 2000; Tidd et al, 2001). These studies suggest that the use of multidisciplinary teams to co-operate during product innovation process is a critical factor in managing success.

A sound practice for multidisciplinary teams is that they should be mainly assembled from a wide range of people who have different backgrounds. Multidisciplinary teams have an aim to share and combine different knowledge, skills, experience and perspectives in solving problems and reach consensus

altogether. Experiments indicate that groups/teams have more to offer than individuals in both fluency of idea generation and in flexibility of solutions developed, and high levels of teamworking tend to be suitable for the potential on any innovation task (Tidd et al, 2001). Multidisciplinary teams can be grouped together, either as a temporary project team or a permanent venture group. The success of the Apple computer is based on the corporation ethos of 'thinking differently' and the team of heterogeneous backgrounds and extraordinary taste. Steve Jobs at Apple includes artists, poets and historians into the product development team (Peters, 1997). Marzano (1998, 16) describes an integrated process, called 'High Design', which was claimed to support the high complexity of new products that this process needs to incorporate 'all the skills on which design has historically based itself, plus all the new design-related skills' which are needed to respond to complexity and challenges of the present and anticipate those of the future. Marzano asserts that the high design process should be based on the fusion and interaction of high-level skills, including designers, psychologists, ergonomics, sociologists, philosophers and anthropologists.

Pinto and Pinto (1990) suggest that the higher the level of in-house cross-functional cooperation, the more successful the outcome of new product development. However, recent studies critically argue that the integrated multidisciplinary teams should not only employ in-house functions, but also need to extend to outside professionals, such as customers & suppliers (e.g. Robert, 1995; Marzano, 1998; Tether, 2000; Tidd et al, 2001), lead users (Hippel et al, 2001); external designers (Jevnaker et al, 1998; Bruce et al; 1998; Kelley, 2002); and university (The Design Council, 2001a). The Design Council and DTI (2000) studied the success of the UK companies in the development of innovative products. This study mentions the importance of collaboration among organisations and suggests that in-house innovation teams should extend to different external organisations. This study also illustrates the successful

examples of product innovation which in-house innovation teams are composed of other external organisations. For instance, Tony De Rivaz, the inventor of Logiblocs game, worked closely with a series of partners –an electrical company, graphic designers, PR experts, and an overseas production company during the new product development process. BAE Systems also worked with a number of external specialists when the company was developing Silicon Gyroscope: working with three universities for advice on various aspects of the development project, and to form a partnership for fundamental research; working with oversea manufacturers as partnerships; and working with a marketing consultancy. Moreover, the collaborative project between design consultancies and their clients are generating an increasing number of innovative products in the market. For example, the UK Cambridge Consultants Ltd and the German Institute of Microtechnology Mainz worked together to exploit micro-medical technology and develop the medical devices for the healthcare product (Cambridge Consultants, 2001). The UK Design Consultancy TKO worked with a small inventive engineering company, Monotub worked together in the creation of a radical design of washing Machine, Titan (Grinyer, 2001). The IDEO design consultancy has worked with many clients, such as IBM and Steelcase in the development of successful innovative products (see Kelley, 2002). It is suggested that 'design alliances' -companies' co-operative alliances with external design expertise are valuable for product innovation and business success (e.g. Jevnaker et al, 1998; Freeze, 1998; The Design Council, 1998, Bessant, 2002).

Furthermore, in the last twenty years, there are a growing number of collaboration between university and industry, such as in USA (see Carboni, 1992) and European countries (see Keeble et al, 2000; Fotana et al, 2003). A number of policies are implemented to support the transfer of knowledge from university to companies, such as establishment of legal frameworks, creation of technology transfer offices inside universities, increasing the mobility of

researchers to industry, and cooperative R&D programmes (Fotana et al, 2003). For example, in the UK, a Teaching Company Scheme (TCS) aims to support the link between universities and companies by encouraging the transfer of knowledge from academic to commercial practices. A number of studies suggest that the TCS programme has a significant impact on the enhancement of innovation capability of firms (See Inns et al 1998; Woolley, 1999; Jones et al, 2000; Libscomb et al, 2001)

In short, many researchers, as mentioned above, indicate that the use of multidisciplinary teams is a critical factor which contributes to the success of the development of innovative products. Significantly, innovation teams should not be limited to be within organisations, but extended to external organisations. The recent findings suggest that organisations are increasingly interested in collaboration across their organisational expertise. .

In Conclusion: Regarding both theoretical and empirical studies, they suggest that collaborative networks of heterogeneous individuals and organisations are suitable for innovation. My study believes that collaborative networks of heterogeneous organisations are likely to be an appropriate type for the development of innovative products in the post-industrial economy.

2.8 CONCLUSIONS

Chapter 2 reports both theoretical and empirical studies on organisation networks related to the development of innovative products. The details of each section summary are:

Section 2.1 defines network as a system of interacting parts and their relations. It indicates that a coherent set of relations among interacting parts is an essential

part within the concept of a network. It also suggests that innovative products would be critically benefited by establishing a network among organisations.

Section 2.2 suggests six key aspects which tend to affect organisational changes in the post-industrial economy: the necessity of flexibility within organisations, the diffusion of information technology, complex conditions of the post-industrial economy, the importance of information and knowledge, the attempt for lean production, and the benefits of business clustering or grouping.

Section 2.3 reports seven theoretical perspectives which underlie the existence of organisation networks. Based on these perspectives, I believe that the 'virtual organisations' perspective is appropriate for the development of innovative products in the post-industrial economy.

Section 2.4 reviews the existing four models of organisation networks which are recently becoming contemporary archetypes in new product development: supply-chain relations, strategic alliances, systems of innovation, and technological networks. I argue that these models of organisation networks are replacing an individualistic approach.

Section 2.5 indicates the advantages of organisation networks in three main levels: the entire networks, each individual organisation, and the product development process. It suggests that networks facilitate and sustain innovation and flexibility on these three levels. Based on these findings, I strongly affirm that organisation networks are a prospective product development process in complex environments.

Section 2.6 identifies three types of organisation networks: centre-focused networks, hierarchical networks, and collaborative, decentralised networks. By

analysing these three types of organisation networks with two system theories: the idea of mechanistic systems and the idea of living systems, my study suggests that collaborative, decentralised networks are appropriate for the development of innovative products in complex environments.

Section 2.7 indicates the type of collaborative, decentralised networks. It suggests that the collaborative networks of heterogeneous organisations are likely to be appropriate for the development of innovative products by the analysis of both empirical and theoretical studies.

To sum up, as Drucker (1993, 90) argues that, in the knowledge-based economy,

"Businesses must believe that nothing matters as much as satisfying the material wants and needs of the community; and in particular, that no product or service is nearly as vital to economy and community as the product or service our business produces and delivers... Organisations must be self-centred, be specialised in their own competence and discharge only one task."

My study argues that an individual-centred system that Peter Drucker described tends to be inappropriate for organisations that need to develop innovative products in complex conditions of the post-industrial economy. The individual approach reflects, broadly speaking, the consequence of the Western thinking which is evident in business and educational systems every day (NACCCE, 1999; Robinson, 2001). The economic and educational ideologies, recognised as the model of the 19th century, concentrate on 'septic focus', deductive reason and scientific evidence (Robinson, 2001). Robinson explicates that they tend to examine a problem in isolation from its context and lack comprehension of the holistic picture. They try to identify the particular cause and potential effect without trying to observe and understand a broader problem. I agree with

Robinson (2001, 201) suggesting that in the interests of the industrial economy focusing on the individual and deductive approach by forgetting the connections between things or the ecology of things, 'we have wasted or destroyed a great deal of what people had to offer because we couldn't see the value of it. Along the way we have jeopardized the balance of human nature by not recognizing how different elements of our abilities sustain and enrich each other' (Robinson, 2001, 203).

An individual-centred approach tends to encourage individual organisations to focus on their specialised production, rather than innovation. Adam Smith suggests that the prosperity of the individuals and the whole economy depends on the 'invisible hand' which is the emergent property of self-interests. My study argues that the individual system misses the dynamic power of the relations and interactions or networks of individuals, which provide flexibility, creativity and innovation. Some studies in different areas: biology (living, complex, or self-organising systems), social systems, physics (chaos), and economics (regional clusters and grouping of organisations) suggest that the relational and cooperative or networking system is able to be open, responsive and adaptive to complex and changing environment. It also has abilities to learn from perpetuating and mutually interacting of interrelating parts, and abilities to innovate from their relating processes. Moreover, the level of complexity and organic relations within the networking system tends to possess smart, creative awareness. My study suggests that these qualities of the networking system tend to benefit individuals and the whole economy for creativity and innovation, rather than the individual system. Therefore, I argue that organisations within networks tend to be more stable than stand-alone, specialised organisations in the economically complex conditions of the post-industrial economy. I advocate the development of networks of organisations who innovate collectively rather than inserting different specialists into a specialised organisation.

Robinson (2001) suggests that the development of human powers of creativity and innovation is vital, mentioned by government and businesses throughout the world in the 21st economy, and the emphasis on education and training is the key. Three key aspects of our human abilities are needed for organisations and businesses: (1) being creative, (2) being able to generate ideas for new products or services (innovative), and (3) enabling to be flexible and adaptable to changing surroundings. To thrive these creative abilities, Robinson (2001) reinforces my argument suggesting that the education or business system focusing on the individual and deductive approach is not compatible. It should focus on the real understanding of the nature of creativity (an integration of different ideas and experiences that were previously unconnected, and being stimulated by the work, ideas and achievements of other people) and a systemic approach (the connections between things or the ecology of things) (NACCCE, 1999; Robinson, 2001). In order to encourage networks of multidisciplinary organisations to work together successfully in the development of innovative products, as a result, the systemic approach and the connections between one another are necessity. My study points to a set of relations among interacting heterogeneous organisations. Therefore, my study aims to investigate critical factors which enable the success of working relations among collaborative organisations in the development of innovative products.

CHAPTER 3: PILOT STUDY AND RESEARCH METHODOLOGY

INTRODUCTION TO CHAPTER 3

Chapter 2 suggests a network feature, collaborative networks of multidisciplinary organisations in the development of innovative products. It suggests that understanding relations of multidisciplinary organisations is critical to achieving collaborative networks.

Chapter 3 describes two main pilot studies. It also describes the scope of the study research and the research methodology. Moreover, it illustrates the entire structure of the empirical network case study research and introduces the four network case studies. The following sections are:

Section 3.1 describes two pilot network case studies: (i) The UK Millennium Products and (ii) Collaborative product development.

Section 3.2 describes the research rationale and approach, entitled network case study.

Section 3.3 identifies the framework of the network case study; contractual collaborative networks of multidisciplinary organisations in the successful development of innovative products.

Section 3.4 describes four criteria of social science standard directing network case study design: (i) Construct validity, (ii) Internal validity, (iii) External validity, and (iv) Reliability.

Section 3.5 describes main concerns in designing network case study process. It also defines the framework of network case study design: (i) multiple network case studies and (ii) theory testing.

Section 3.6 identifies ten key factors and one hypothesis which are used to investigate each network case study.

Section 3.7 describes the data collection protocol of the network case study, including (i) three main data collection methods, (ii) four stages of data collection approach, and (iii) the research data collection tool.

Section 3.8 describes the analysis methods of the network case study, including (i) individual network case study analysis, and (ii) cross-case network case study analysis.

Section 3.9 depicts the summary of the protocol of the examination of four network case studies.

Section 3.10 summarises the details of the four network case studies.

Section 3.11 summarises the context of Chapter 3

3.1 PILOT NETWORK CASE STUDY

The pilot network case study aims to explore the relationship between organisation networks and the successful development of innovative products. It searches for existing collaborative networks of multidisciplinary organisations in the UK. I have used 'the visibility of innovative products in the market' as a key indicator of successful collaboration. There are two pilot network case studies; Pilot Study 1: The investigation of successful innovative products of the UK Millennium Products Awards, and Pilot Study 2: The investigation of existing collaborative product development projects.

3.1.1 PILOT STUDY 1: THE UK MILLENNIUM PRODUCTS

Pilot study 1 was simultaneously conducted along the process of literature review during April – September 2001. It aimed to achieve the following:

- ☐ To investigate external conditions which produce the need for product innovation
- ☐ To examine the advantages of links with other organisations
- ☐ To study existing networking systems and processes and how they relate to product innovation
- ☐ To select case studies of industrial organisations employing strategic network for in-depth research

I have decided to select innovative products of the UK Millennium Products Awards winners, initiated by The Design Council, as the main sample for this research. These awards, granted during 1997 -2000, were based on the achievement of creativity and innovation in the UK organisations in the following aspects: (i) opening up new opportunities; (ii) challenging existing design conventions, (iii) demonstrating environmental responsibility; (iv) using new or

existing technology; (v) solving a key problem and (vi) showing clear user benefits.

Regarding the initial research from the Design Council, there were 26 innovation issues/processes identified as the factors contributing to the success of the award winning innovative products, such as Brainwave-Driven, Environmental Push, User Needs, Market Testing and Futures & Forecasting. The category, 'Links with other Organisations' was selected. One hundred and thirty eight innovative products were chosen. Mainly, they were initiated by small and medium-sized organisations. Innovative products were selected from a wide range of product areas, for example a print measuring instrument (ACME Plate Reader), an automatic public toilet (Adshel Automatic Public Toilet), a medical product (Discam), a smart textile (Gorix) and an emission control device (EVEC). 138 postal questionnaires (see the example of Questionnaire 1 in Appendix A-2) were sent out to Company Directors, Technical/R&D/Design Directors or Head of Engineering/Design Department. Almost 56 percent responded. The questionnaire comprised two main sections: (i) design/company information and (ii) design/company visions. The details of research design, questionnaire design and Pilot Study 1's analysis are shown in Appendix A-3.

Based on the analysis of the questionnaire section one, Pilot Study 1 indicates five main reasons driving organisations to sustain the development of innovative products:

- ☐ Opening up new business opportunities
- ☐ Offering design that is responsive to human needs
- ☐ Challenging existing conventional design
- ☐ Wanting to be the business leader in the market
- ☐ Responding to market needs

On average, organisations linked with one or two external organisations. Two core external sources revealed high percentage: research institutions (universities and laboratories) and production suppliers (new technologies of components and systems). Also, Pilot Study 1 reveals five key management reasons to link with other organisations:

(i) Resource Management: to access specialised knowledge and skills, to obtain training and to accrue technology transfer benefits

(ii) Time Management: to reduce time during product development process

(iii) Cost Management: to reduce R&D cost and to get external funding

(iv) Risk Management: to share risk and liability

(v) Product/Design Management: to improve design appearance, to test/ evaluate design and to ensure design meets users' needs

Moreover, Pilot Study 1 reveals different ways of establishing links/relations with other organisations:

- ☐ Through directing contact for specific purposes
- ☐ Through long-term personal and professional relationships
- ☐ Through the established networks, such as local supplier networks and Internet
- ☐ Through attending public events, such as competitions, seminars, exhibitions and conferences
- ☐ Through the UK government initiative schemes, such as Teaching Company Scheme, Business Links and DTI Link projects

Furthermore, their relations with other organisations were mainly employed in the following stages during the product development process, including (i) Research and Development, (ii) Concept Testing (iii) Idea and Concept Generations and (iv) Manufacture. Pilot Study 1 indicates that, firstly, fifty three percent of their relations with other organisations were 'centre-focused networks', to acquire a

specific need from external sources rather than collaborate with them. Secondly, thirty nine percent formed 'collaborative networks.' Thirdly, twenty two percent worked with other organisations across different industries. Finally, one-fifth did collaborate together in the design-planning process.

Based on the analysis of the questionnaire section two, 'Design/Company Vision', Pilot Study 1 suggests that organisations believed that their links/relations with other organisations would support four core issues in the future:

(i) Supporting innovative design in products, processes and/or services

(ii) Speeding up innovative design transfer to market

(iii) Generating more innovative design

(iv) Changing the way they do their business

Also, organisations believed that their links with other organisations could contribute to a number of design vision possibilities, as illustrated in Diagram 3-1:

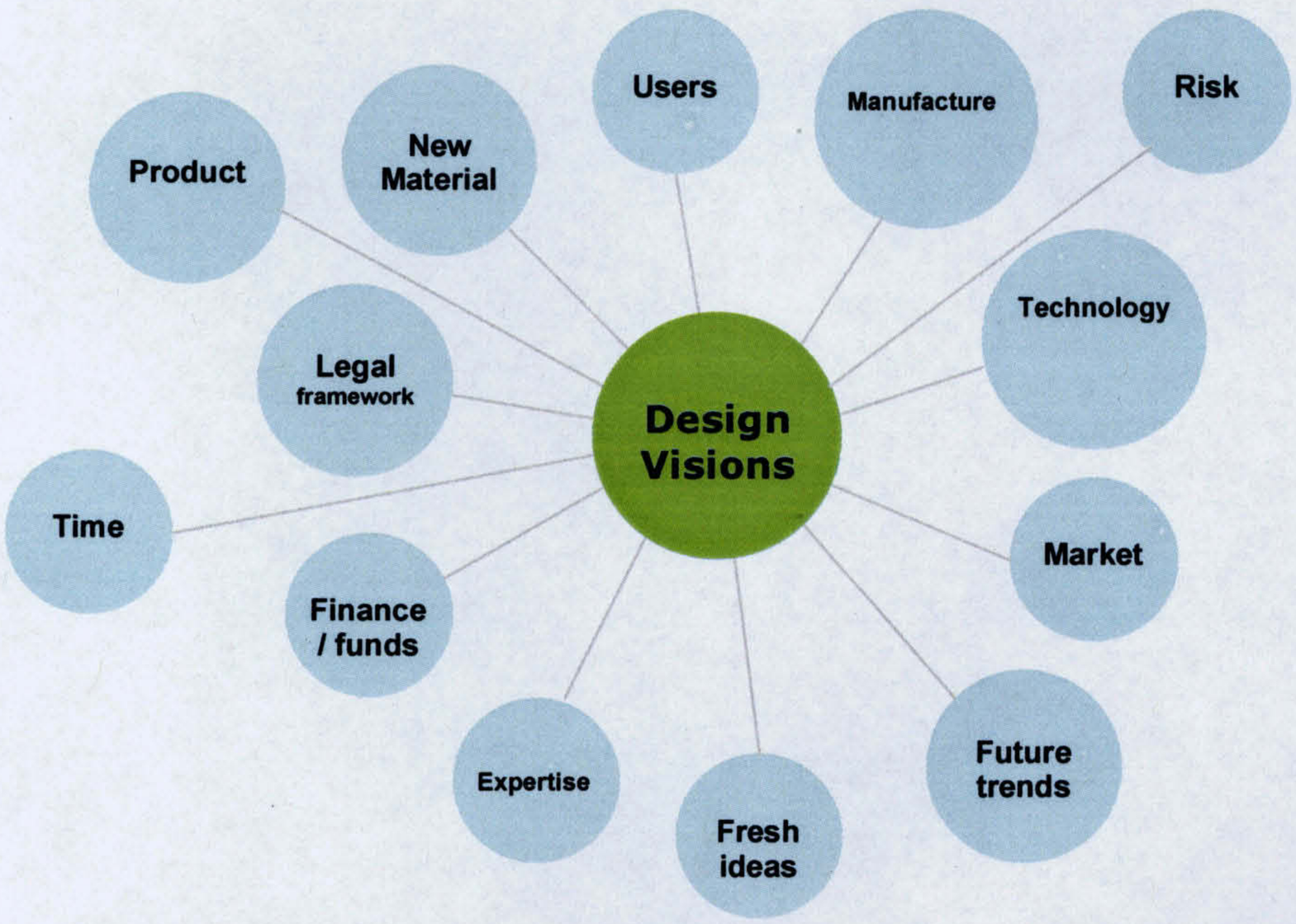


Diagram 3-1 illustrates a number of design vision possibilities generated by other external organisations

As shown in Diagram 3-1, a number of design vision possibilities are:

- ☐ Users' requirements, judgements and problems
- ☐ New fabrication/manufacturing process
- ☐ Technology transferring and licensing
- ☐ Customers' demands and viewpoints
- ☐ Marketing information, awareness and expertise
- ☐ Future trends within industries
- ☐ Fresh ideas and viewpoints and expanding and sharing ideas
- ☐ Specialised skills, resources, equipment and knowledge
- ☐ Financial and funding supports, such as R&D cost reduction, internal financial strength and assistance
- ☐ Legal supports, such as IPR, marketing and manufacturing process
- ☐ New materials and changes in raw materials
- ☐ R&D risk reduction
- ☐ Time reduction in R&D process and knowledge acquisition
- ☐ Increasing product value, such as design efficiency, value-added design solutions and design testing.

Based on these design vision possibilities, I would suggest that links with other external organisations can provide a holistic view for organisations towards the development of innovative products in the future.

The outcomes of Pilot Study 1 reflected the beneficial relationship between organisation networks and product innovation, and, in particular, helped me to learn and understand the conduct of UK manufacturing firms, especially SMEs, underlying their innovation success. According to the detailed analysis in each questionnaire, it showed that each innovative product tended to have a unique process and detail of organisation networks. The UK SMEs also tended to subcontract external organisations, rather than collaborate with them. Pilot Study

1 did not provide enough evidence to identify that, particularly the contexts of collaborative networks among multidisciplinary organisations in the development of innovative products because it did emphasise the network benefits rather than the details of collaboration. As a result, Pilot Study 1 revealed less satisfaction in the framing of the contexts of collaborative networks. This was rectified in Pilot Study 2.

3.1.2 PILOT STUDY 2: COLLABORATIVE PRODUCT DEVELOPMENT

Pilot Study 2 aims to search for existing models of collaborative networks between multidisciplinary organisations in the development of innovative products in the UK. Reviewing so far, two distinctive scales of collaborative networks are identified: (i) micro system (i.e. collaborative projects) and (ii) macro system (i.e. industrial districts or regional clusters). These scales are distinguished by the characteristics of collaborative networks and their complex emergence. A micro system is a self-organsing networking team of independent, multidisciplinary organisations which temporarily interact and work together to achieve a particular goal. The macro system refers to the dense, complex networks of social and professional relationships within a region, district or industry. Regarding these network scales, the micro system is selected as the main study focus. This is because I am interested in the relationships within collaborative networks that developed among multidisciplinary organisations. Also, this will permit me to delve qualitatively into better research information than the macro system as posed by my research limitations (see reasons in Section 3.3.3). I call the collaborative network at the micro system: 'contractual collaborative projects'. It is defined as *the collaboration of at least two non-directly competitive, multidisciplinary organisations that are contractually committed to work together by means of sharing their efforts in the development of an innovative product.*

To do so, there are two main investigation sources:

(1) Potential cases of collaborative networks from the findings of Pilot Study 1

(2) Existing successful innovative products in the market, particularly focusing on cases of the collaborative product development between design consultancies and other specialist organisations

Two sets of postal questionnaires were sent out to the two selected groups. First, Questionnaire 2 (as shown in Appendix B-3), were sent out to 28 organisations derived from the findings of Pilot Study 1. Secondly, Questionnaire 3 (as shown in Appendix B-4), designed for design consultancies was sent to potential respondents in 8 consultancies. I targeted project leaders, Managing Directors and industrial designers. The designed questionnaire comprised two main parts:

Part 1 investigating general details of collaborative network projects underlying the known success of innovative products

Part 2 investigating factors that might be critical to successful collaborative development of innovative products. It also evaluates key hypothesis.

There were 20 responded collaborative projects. Four potential network case studies were selected to further sequentially contact (see the summary details in Section 3.10). Eight critical factors which underpinned the collaborative product development success were identified:

(i) Top management commitment and support

(ii) Trust in the abilities of partners

(iii) Strong culture of innovation/creativity

(iv) Effective communication

(v) The collaborative project team's commitment

(vi) Open information exchange

(vii) Open discussion about all issues related to innovative products

(viii) Joint problem-solving in critical stages

3.2 NETWORK CASE STUDY RATIONALE AND APPROACH

As mentioned in Section 2.1, I have defined the concept of a network. My study suggests that the coherence of relations among interacting parts is more important than each individual part. Relations are emergent properties which cannot be found from the sum of its parts or each interactive part. For that reason, to understand the underlying critical factors of a relation of interacting parts is to study the sum of a whole part, not a part of the sum. This means to understand the underlying critical factors of collaborative networks between multidisciplinary organisations is to study a relation of the networking organisations, not from an organisation within networks.

Although little comparative work exists, some work has been done. However, in the main study, the identification of significant factors of the success of collaborative product development has been reflected from only one organisation within collaboration, rather than the sum of the collaborative organisations. First, Bruce et al (1995) identified significant factors affecting outcomes of collaborative product development in the information or telecommunications technology sectors. Bruce et al quantitatively investigated selected samples of individual organisations, rather than the organised whole of interacting organisations within collaboration. Secondly, Sale and Wilkinson (1999) identified significant issues in setting out the conditions for managing collaborative product development across multidisciplinary organisations. Sale and Wilkinson reflected upon key issues for design management from their experience as a design-academic partner in collaboration. Instead of using a reflection of a participant perspective, my study uses the qualitative research method, named 'network case study'. This research methodology is based on the reflection of the collaborating participants within the project. Based on Fuller's theory of synergy (Fuller, 1975), understanding the

relationships of the whole system tends to reveal the underlying factors, behaviours, structure, and dynamics of the collaborative network. Fuller (1975) asserts that the advantage of analysing the whole network system is to investigate hidden causes which cannot be identified by the lack of understanding the relationships of the whole systems.

I have assumed that to understand critical factors of the success of the collaborative network between multidisciplinary organisations, as posed by the research aims in Section 1.6, all organisations participating in the collaborative network need to be investigated. As Wasserman and Faust (1994, 5) suggest that, in social network analysis, 'the difference of network analysis from other unit of analysis is the unit of analysis is not individual, but an entity consisting of a collection of individuals and the linkages among them'. Therefore, the relations of the collaborating multidisciplinary organisations are the central focus of analysis.

To analyse the relational structures or relations, I have decided that the network case study approach would be the most suitable research strategy in comparison with other research strategies, such as survey, experiment and history. In this regard, I have considered the view of three exemplary authors who reflect the importance of the case study method to investigate the collaborative network. As Yin (1982) suggests that the case study method allows the investigation to retain the holistic and meaningful characteristics of real-life events, such as individual life cycles, organisational and managerial processes, and international and industrial relations. Marshall and Rossman (1999) also assert that the case study method is suitable for delving into complexities and processes. I also detail three supportive arguments deployed to support my decision.

I attempt to search for a specific form of the network feature, collaborative networks of multidisciplinary organisations in the development of innovative products. According to the two pilot studies, most organisations prefer to develop their innovative products by subcontracting external organisations rather than collaboration. Consequently, it would be very difficult to find a large number of samples. Thus, the survey would be an inappropriate approach because this has to deal with statistical patterns which can be summarised from a large number of relevant samples. Also, a survey is unlikely to investigate the structural relation of the collaborative network.

Secondly, to investigate critical factors within the selected network case study, it would be extremely difficult to understand the underlying critical factors, structure, integral aggregated behaviours and dynamics of collaborative networks without understanding relations of collaborating organisations, as I referred to Fuller (1975) above. From this point, I have decided that the experiment research approach would not be suitable because I cannot control the defined variables (such as collaborative development process, co-operation and mutual relationships) and manipulate behaviours of collaborating organisations directly, precisely and systematically. These normally occur in a laboratory setting.

Finally, to understand the richness of the whole collaborative systems and behaviours, the study must rely on, not only retrieved documents and cultural and physical artifacts, which are dominating in the historical method, but also from systematic interviews and/or direct observation as the main sources of evidence. As a result, I have decided that the historical method would be totally inappropriate. However, reviewing retrieved documents would be supportive of parts of the network case study approach.

3.3 NETWORK CASE STUDY FRAMEWORK

As mentioned in Section 3.1.2, contractual collaborative networks of multidisciplinary organisations in the (successful) development of innovative products are the network case study. Therefore, each network case study comprises three main criteria:

3.3.1 THE LEGAL CONTRACT

Contractual collaborative networks are based on a legal contract, not social, cultural and institutional relations. Based on the study aims, the legal contract would help the study to define a certain boundary of the organised networks. Such boundary would lead to effective examination of the relations between the collaborating organisations. One might assume that the legal contract is a relational structure that forces them to work together. However, I would argue that the successful development of innovative products is not only depending on the legal contract, but on how the collaborative organisations work together within the collaborative product development processes and sustain their relationships.

3.3.2 THE SUCCESSFUL DEVELOPMENT OF INNOVATIVE PRODUCTS

As mentioned in Section 1.3, I have decided to focus on a particular type of innovative product, which is 'new products to the world' and 'high improvement of existing products.' Turning to the point of the successful development, two schools explain how to define the measurement of innovative product development success. First, management schools define successful development by employing the factual economic indicators, such as the return on investment, company profit, market share, sales, market dominance and customer satisfaction (Song et al, 1997; DTI, 2001). Secondly, design schools, especially in an area of industrial design, define it by accepting future possibilities of

innovative products which would be used as a viable prototype on the project level. Such prototype could be mass-produced in industrial processes. Regarding both definitions, my study embraces the thought of design schools, the visibility of innovative products.

3.3.3 MULTIDISCIPLINARY ORGANISATIONS

In any contractual collaborative networks, I have defined contractual collaborative networks, as mentioned in section 3.1.2.

In addition, I have decided to select recent contractual collaborative networks, where their collaborative results, innovative products, have been sold in the market. This is because to deal with current collaborative product development projects which are still in development process, it would be extremely difficult to access required information. I have recognised three main difficulties. First, I, as a researcher, am not a part of collaborative networks. Thus, it would be difficult to gain co-operation from the collaborative organisations. Secondly, collaborative organisations may fear that their sensitive information, such as innovative product attributes, would be revealed to outside competitors before an innovative product is produced and launched to market. Finally, innovative product development process is mostly involved with trials and errors. This would be difficult to control my time during the research. I also have decided to focus on the recent collaborative projects which have been achieved since 1997.

3.4 CRITERIA OF NETWORK CASE STUDY DESIGN

I have decided to adopt four criteria of social science standard, which is suggested by Yin (1984) to direct my network case study design. The four criteria are: construct validity, internal validity, external validity and reliability.

3.4.1 CONSTRUCT VALIDITY

Construct validity aims to establish correct operational measures for the concepts being studied. Yin suggests that to meet the examination of construct validity, two steps needed to be ensured: (i) selecting the specific types of changes that are to be studied, and (b) demonstrating that the selected measures of these changes do indeed reflect the specific types of changes that have been selected. In this regard, Yin asserts two means which increase construct validity. The first is the use of multiple sources of evidence, in a manner encouraging convergent lines of inquiry, and this tactic is relevant during data collection. The second tactic is the establishment of a chain of evidence during data collection process.

3.4.2 INTERNAL VALIDITY

Internal validity is the concern for the verification of conclusions. To establish this validity in explanatory case studies, for example, one normally needs to establish a proposition of a causal relationship, whereby a condition X causes a result Y. Yin mentions that the problem of making conclusions from a case study phenomenon frequently derives from some earlier occurrence based on interview and documentary evidence, which could not be directly observed. For that reason, conclusions may be misleading. Yin suggests that to deal with this problem the analytical strategy of case study approach needs to be defined at the early stage. Yin highlights that the analytical strategy would help to address internal validity.

3.4.3 EXTERNAL VALIDITY

External validity is the concern for the domain in which a study's findings can be generalised. Yin mentions that external validity has been a major barrier in conducting single case studies. In this regard, Yin argues that critics are confusing a single case study with a sample in the situation of survey research. In any survey research, samples, if selected correctly, can readily be statistically generalised to a large universe. This analogy of 'samples' and 'universes' is inappropriate when dealing with single case studies. This is because survey research relies on statistical generalisation, whereas single case studies rely on analytical generalisation. Also, Yin asserts that to generalise a specific theory (a particular set of results) to broader rational explanation, the theory would be examined through replications of the findings in multiple case studies. Yin suggests that this 'replication logic' would increase external validity. Furthermore, Yin (1984, 40) claims that 'once replication has been made, the results might be accepted for a larger number of similar case studies, even though further replications have not been performed.'

3.4.4 RELIABILITY

The objective of reliability is to demonstrate that the operations of a study can be repeated with the same results. Its goal is to ensure reliable research procedures and results. Also, it is to minimise the errors and biases in a research. Yin mentions that in the past, case study research procedures have been poorly documented, making external reviewers suspicious of the reliability. Yin suggests that a case study research needs to document the procedures, called case study protocol that is to allow other investigators and/or external reviewers follow earlier documented procedures to produce the same results. Also, Yin asserts that the general way of the anticipation of reliability is to identify as many steps of case study operations as possible and to concern on the review of these operations.

In short, these four criteria are embraced and used as guidelines in designing the entire network case study process.

3.5 NETWORK CASE STUDY DESIGN

I have concerned three aspects in designing the process to approach network case study.

First, it is widely recognised that the development of innovative products involves the sensitive issue of product confidentiality. To investigate the network case study, collaborative networks of multidisciplinary organisations in the development of innovative products, inevitably my study has to be involved both directly and indirectly with this issue. Though my study does not focus on the details of innovative products, it examines collaborative networks in relation to product innovation. As a result, I have assumed that approaching a network case study would be very difficult.

Secondly, I have assumed that anticipated research participants who have been involved in the development of innovative products have a busy role. Mainly, my study needs to participate with persons who worked as the main points of contact during the collaborative network. Their positions in organisations would be, for example, Managing Directors, Head of R&D Department, or Project Leaders. As the nature of their works, these people would not be easy to get contact with because they are busy with their routines works.

Thirdly, because of my research position as an outsider in a network case study, I have assumed that it would be very difficult to directly observe and to access and collect all related documents during collaborative networks. It also would be very

difficult to absorb all required information and tiny details of the whole collaborative process.

As posed by these three main concerns, I decided to employ theory testing to investigate a network case study. This concept would support my study to focus on underlying critical factors within collaborative networks and avoid too much distraction of anticipated research participants' busy times. The key factors and a hypothesis (see details in Section 3.6) are used as a theory to investigate the network case study.

However, to increase the external validity of the research outcome, I have decided to approach multiple network case studies. As Yin (1984, 48) suggests that 'in comparison with single case study, multiple case studies are often more compelling and the overall study is regarded as being more robust.' Therefore, I have assumed that the theory will be examined through replications of findings in multiple network case studies. Yin describes the concept of 'replication logic' that this logic is to access a few rare case studies, for example, two or three cases which the same results are expected from each of the case studies. Yin contrasts the replication logic with a 'sampling logic' that the replication logic follows particular, analytical cross-experiment rather than statistical within-experimental arrangement. On the contrary, Yin asserts that the sample logic is to find repetitions of multiple respondents, which is normally found in a survey.

Turning to the point of selecting multiple network case studies, Yin (1984) suggests two replication types of multiple case studies: (i) a literal replication and (ii) a theoretical replication. Yin details both types that, first, the literal replication is to select multiple case studies, two or three cases, which can be predicted to reveal similar results. Secondly, the theoretical replication is to select a few

opposite groups of multiple case studies, three to four cases per each group, which can be predicted to reveal contrary results. Based on the two replication types, I decided to adopt the literal replication by selecting three similar case studies. As mentioned in Section 3.2, the network case study, collaborative networks of multidisciplinary organisations in the development of innovative products in the UK, is difficult to find. Therefore, to find an opposite case would be very difficult, as posed by my main three concerns.

Please note that during the initial network case study plan, I decided to approach three similar case studies. However, the data collection of Case Study 3 was less satisfactory due to the sensitive issue of product confidentiality bound by the legal contract between organisations (see more details of Case Study 3 in Chapter 6). As a result, Case Study 4 had been added up in order to strengthen the research outcome.

3.6 THEORY TESTING

To summarise, I assumed that ten main issues, leading to ten factors and one hypothesis, would be critical factors for the success of collaborative networks of multidisciplinary organisations in the development of innovative products. This is because these ten main issues are identified from the following related subjects to my study areas, including key factors of new product development within organisations, significant elements within the management of organisation networks, and important applications of living systems related theory. The ten main issues are:

3.6.1 ADAPTABILITY

One of the main attributes of living systems is the ability to be adaptable to change. Capra (2002, 202) uses the ecological principle of 'dynamic balance'

which sustains the ecological systems alive that 'an ecosystem is a flexible, ever fluctuating network. Its flexibility is a consequence of multiple feedback loops that keep the system in a state of dynamic balance.' Inevitably, from this viewpoint, the adaptability of living, ecological systems results from the adaptability between the systems cells/components/organisations to sustain the whole system. If we apply this approach to the existing example of organisation networks, Brennan and Peter (1995) studied the correlation between inter-firm adaptability and the organisation relationship and suggested that less adaptation tends to cause deterioration in the relationship which this leads to a noticeable increase in the level of conflict. As a result, increasing in the level of conflict reveals these symptoms: very little mutual adaptation and lower level of perceived mutual trust and the perceived quality of information exchange. In a nutshell, I suggest that the adaptability between organisations within collaborative networks would be a critical factor.

3.6.2 COMMITMENT

In the success of new product development within organisations, a number of studies suggested that commitment, especially from Top Management is essential (e.g. Cater and Williams, 1957; Cooper, 1979; Twiss, 1992; DTI & CBI, 1994; Holland et al, 2000; The Design Council, 2000a). Burton-Jones (1999) asserts that organisation networks fail because of the lack of commitment among the networking organisations. Burton-Jones (1999, 139) emphasises the balance of commitment as important because 'organisational networks tend to be organised along democratic lines rather than controlled by a single firm as the central power, an equal spread of commitment from the members is important.' As a result, I propose that commitment is a critical factor to the success of collaborative networks.

3.6.3 COMMUNICATION

Trott (1998) reminds us that innovation itself is an information-interaction process. A number of studies suggested that effective communication can build up an environment of continuous innovation (Tushman et al, 1986; DTI, 1996a; DFEE, 1997; DTI & CBI, 1997; DTI, 1998). Effective communication has to support both formal and informal communication process. Effective communication provides a value of opening the truth of information, an opportunity to share and exchanging potential ideas, views and tacit knowledge. Particularly, focusing on the successful development of innovative products within organisations, it is suggested that having the effectiveness of communication between participating functions is a key factor (Carter and Williams, 1957; Langrish et al, 1972; Cooper, 1979; Holland et al, 2000). As a result, I suggest that effective communication process is a critical factor to the success of collaborative networks.

3.6.4 INTERDEPENDENCY

Blau (1968, referred by Grabher 1993a, 9) claims that understanding interdependency is crucial for a long-term view. Grabher (1993a) suggests that interdependency, referred as 'mutual orientation' is developed through interaction process. Mutual orientation creates 'invisible bonds' that the components/ organisations within the network can share a common language. In the case of organisation networks, it is suggested the common language, shared through these invisible bonds is more on: technical matters; planning; contracting rules; standardisation of processes, products, and routines; product and process adjustments; organisation knowledge and logistics coordination; and less on the aspects of business ethics, technical philosophy, and the handling of organisational problems (Johanson et al, 1991; Grabher, 1993a). From this viewpoint, mutual orientation would be an extremely critical part of the network

because it builds up invisible bonds of collaborative organisations which allow information sharing and the network survival.

3.6.5 WELL-ORGANISED PROCESS

A number of studies suggested that the successful development of innovative products within organisations is based on a good management of innovation process (Bright, 1968; Rothwell, 1972; Booz-Allen & Hamilton, 1982; Trott 1998). Johne and Snelson, who studied the success of 20 British and 20 US firms, suggest that their companies success was closely correlated with how well the product innovation process had been managed, such as having an explicit strategy, using formal product planning procedures, exploring a wide range of options and using integrative organisational arrangements (referred by ESRC, 1997). Also, the study of Hart (1995, 21) suggests that 'the efficient execution of the development process, or particular activities within the development process, as critical to new product success.' In short, the evidence suggests that well-organised collaborative (product development) process would be a critical factor.

3.6.6 RECIPROCITY

Gouldner (1960) claims that a norm of reciprocity is a social norm that tends to be universal among our societies across time and cultures (referred by Powell 1991). Blau (1964, 6) asserts that reciprocity implies 'actions that are contingent on rewarding reactions from others and that cease when these expected reactions are not forthcoming' (quoted by Grabher 1993a, 8). In general, reciprocity involves the activities of 'exchanges' (Powell, 1991; Grabher, 1993a). Gouldner (1960) mentioned that focusing on reciprocity tends to sustain exchange and enhance cooperation. Also, Powell (1991, 273) related the reciprocity with a long-term perspective that 'it will encourage the security and stability, which both encourage the search for the new ways of accomplishing tasks, promote learning and the exchange of information and engender trust.' Moreover, the study of

Hart (1995, 30-1) focusing on critical success factors in new product development claims that information, as 'a base currency of new product development process', has a significant role in facilitating both 'an efficient new product development process and achieving functional coordination.' For the former, the transfer of information between the participating groups is a key to establish and maintain credibility. For the latter, the efficient transfer of quality information between the participating groups encourages their coordination. Hart (1995, 31) also asserts that 'evaluative information is crucial and must be disseminated to facilitate communication.' Moreover, Hart (1995) claims that a key resource of exchange in a network among various firms/organisations whose aim is to pool different resources and competencies is information. I am proposing that, exchanges, especially open information exchange are a critical factor to the success of collaborative networks.

3.6.7 RELATIONSHIP

A number of studies suggested that a critical factor in the development and evolution of inter-organisational relations/networks is a satisfaction with relationship, not the length (time) of relationship (Cheung and Peter 1995). The satisfaction with relationship is an essential criterion for commitment in a relationship, particularly the development of close, rather than long-standing one (Cheung and Peter, 1995). Turning into the collaborative development of innovative products, inevitably, this activity is based on the relationship between personal level rather than organisational level (Biemans, 1992; Duysters et al, 1999). As Prof. Sir Alec Broers (1999), Vice Chancellor, Cambridge University asserts that in the last 100 years, the greatest change of innovation has been progressed by a small or large working group, 'the genius of minds combined'. Brennan and Peter (1995) suggest that the establishment of good personal relationships is the most important factor in long-term organisation relationships. In a nutshell, I propose that good personal relationship would be a critical factor.

3.6.8 SELF-REGENERATION

One of the necessities of cells/actors/organisations within/as living systems is the dynamic of self-regeneration, the autonomous abilities to sustain and generate itself or autopoiesis (literally self-making). Regarding the autopoietic system, Maturana and Varela (1987) suggest that living systems are able to couple with and interact with their environment structurally and to continuously produce, repair and perpetuate themselves. Capra (2002, 30) describes the defining characteristic of an autopoietic system that 'it undergoes continual structural changes while preserving its web-like pattern of organisation.' Capra asserts that focusing on the components of the autopoietic system, they continually produce and transform one another in two distinctive ways of structural changes. The first type of structural changes is that the components in the system are able to renew themselves. The second type of structural changes is the components are able to create new structures –new connections in the autopoietic network. From this theory, I have assumed that each organisation within collaborative networks should have an autonomous ability to innovate in order to build up relations with others successfully. In short, the autonomy of innovative abilities of each organisation would be a critical factor.

3.6.9 SHARED EMPOWERMENT

Within living/complex systems, it is suggested that shared empowerment emerges at the edge of chaos. As Waldrop (1992) suggests that the edge of chaos is where the components of a system/network never quite lock into place, and yet never quite dissolve into turbulence either. The edge of chaos is where new ideas and innovative genotypes are perpetually emergent at the edges of the status quo. From this viewpoint, I have assumed that the process of emergence is a process of shared empowerment, resulted from interactions, relations and cooperations between the whole components. To empower new ideas and innovation of this process within collaborative networks, I suggest that the

components or organisations should jointly share their powers (as ideas, experience, knowledge and viewpoints) as a team. To do so, joint problem-solving and decision-making would be critical factors.

3.6.10 TRUST

Many studies emphasise trust as a crucial element in co-ordinating the mechanism success of many organisation networks, such as Italian industrial districts, ethnic business network, and supplier-buyer collaboration (Perry, 1999; Burton-Jones, 1999; Lane, 2002). Lane (2002) claims that trust is increasingly viewed as a precondition for superior performance and competitive success in global economic environment. Trust is initially generated by many reasons, such as social relationships (friendship, kinship, and local proximity), partnership, self-interest and belief, and specialised competence. Significantly, Powell (1991) claims that trust emerges from cooperation of mutual interests and behaviours based on cooperative standards that no one individual can determine alone. Arrow (1974) mentions that trust has a powerful function which could be efficient in any exchange relations (referred by Powell, 1991). This means trust can reduce complex realities of authority and bargaining (Powell, 1991), make relationships more flexible (Nooteboom, 1999), and sustain the network (Thompson et al, 1991).

Within organisation networks, trust has been defined as 'a set of expectations shared by all those [organisations] in an exchange' (Zucker, 1986, 54). Zucker outlines three types of trust in the organisational networks: 1) process-based trust emerges from repeated experience of social or economic transactions, 2) characteristic-based trust rests on distinctive personal/organisational characteristics, and 3) institution-based trust is tied to, for example, unique organisatioal abilities, brands and/or reputations. Scrutinising these three types of trust, De Chernatony (2001, 4) suggests that, through well-conceived and effectively managed brands by focusing on the delivery of distinctive internal

functional abilities and emotional values, 'firms are able to build favourable reputations which enhance the confidence of buyers and users'. He points to 'lever their brand investments, once managers have created consumer trust in their brand's functional superiority, they then seek to build consumers' appreciation of particular emotional values' (De Chernatony, 2001, 5). This leads to the assumption that institution-based trust, especially trust in the functional abilities of collaborative organisations, would be a critical factor.

To sum up, regarding these ten observed issues, I have suggested ten key factors and one hypothesis, as shown in Table 3-1, that they would be critical factors within the success of collaborative networks of multidisciplinary organisations in the development of innovative products:

Table 3-1 illustrates key factors in my hypothesis

OBSERVED ISSUES	KEY FACTORS IN MY HYPOTHESIS
Adaptability	1.Adaptability between organisations
Commitment	2.Commitment to the collaborative product development
Communication	3.Effective communication process
Well-organised process	4.Well-organised collaborative product development process
Reciprocity	5.Open information exchange
Relationship	6.Good personal relationship/Close interpersonal relationship
Self-Regeneration	7.An autonomous innovative ability of each organization
Shared Empowerment	8.Joint problem-solving 9.Joint decision-making
Trust	10.Trust in the abilities of the collaborative organizations
Interdependency	Hypothesis: Each critical factor should have high level of mutuality between the collaborative organisations

Please note, these observed issues are also used for setting up my research questions and for planning data collection tool.

3.7 DATA COLLECTION PROTOCOL

3.7.1 DATA COLLECTION METHODS

As Yin (1984) suggests, to increase construct validity in the quality of case study research, one of the research tactics is to use multiple sources of evidence, encouraging convergent lines of inquiry during data collection. Three main data collection methods are used to investigate the network case study: face-to-face, structured interviews, the review of retrieved documents and questionnaire.

3.7.1.1 FACE-TO-FACE, STRUCTURED INTERVIEWS

Interviewing is described as 'conversation with a purpose' (Kahn and Cannell 1957, 149). As posed by the research design in Section 3.5, I decided to adopt structured interviews with open-ended and close-ended questions that are used as the main method to understand the underlying critical factors. Coolican (1999) describes structured interview that it is the standardised interviewing procedure which includes pre-set questions in a predetermined order. Face-to-face interviews are used during this procedure. Coolican suggests the advantages of the structured interview that it is to help to avoid 'looseness and inconsistency' which accompany interview data gathered by the categories of informal interviews: non-directive interview, informal interview and semi-structured interview. In comparison with the informal interviews, Coolican claims that the structured interview also provides the ease of data comparison and analysis. This is because the informal interviews are difficulties in analysis because answers may consist of a wide variety of qualitative information. The informal procedure could also make data comparison less fair and reliable. Moreover, Coolican asserts that the structured interview reduces interpersonal bias factors.

Furthermore, it can be managed in given low time and effort commitment in comparison with informal interviews which would consume more time and energy because of the length and depth of the interviewing process.

3.7.1.2 QUESTIONNAIRE

A postal questionnaire was ruled out early on in my planning because face-to-face interviews would allow me to interact with interviewees in order to understand in-depth information and to probe other relevant issues related to my research. Postal questionnaire is used instead of face-to-face interviews. I have adjusted the structured interview questions to be a questionnaire. This method turns to be really practical when research participants refuse to participate face-to-face interviews or are very busy with their routines works, as shown in Case Study 2, 3 and 4.

3.7.1.3 THE REVIEW OF RETRIEVED DOCUMENTS

The review of retrieved documents is used to supplement interview and questionnaire data. The documents, including organisation objective, strategy, structure and culture are gathered and analysed. The sources of the documents include published organisational websites, annual reports and/or formal publications. This review is used for the description of the behaviour of collaborative organisations, and organisation details in all case studies. As Yin (1982) claims that this method can provide history and context surrounding case studies. Also, Marshall et al (1999) assert that the review of retrieved documents is rich in portraying the values and beliefs of participants.

3.7.2 DATA COLLECTION APPROACH

Data collection approach comprises four main stages: (1) data collection plan, (2) before data collection, (3) during data collection and (4) after data collection.

3.7.2.1 DATA COLLECTION PLAN

As mentioned in Section 3.2, a relation of interacting parts is the key focus of my study. Based on the method of social network analysis, Knoke et al (1991, 175) mention that, to analyse any network, the structure of relations among actors (parts) and the location/position of individual actors in the network have significant behavioural, perceptual, and attitudinal consequences both the individual units and for the network as a whole. Knoke et al suggest that a relational structure analysis aims to identify the significant positions within a given network of relations that link the network actors. By occupying the positions in a network structure, individual actors have certain connections to other actors, who in turn also occupy unique structural positions. To identify the actor positions in a given network and to determine which actors jointly occupy each position, Burt (1978) suggests two basic alternatives (cited by Knoke et al, 1991). Firstly, 'social cohesion' is the actor aggregation together into a position to the degree that they are connected directly to each other by cohesive bonds (such as staff in R&D department or a group of PhD students in the Design Department). Secondly, 'structural equivalence' is the actor aggregation into a jointly occupied position or role to the extent that they have a common set of relations to the other actors in the network (such as the connections between PhD students and supervisors or of cross-functional teams). Based on these two alternatives, I have adopted the structural equivalence approach. Within a network case study, all collaborating organisations will be approached. I decided to target the structural equivalence of the main points of contact between the collaborative organisations. This means in each organisation, at least one person who worked as the main point of contact will be interviewed. For instance, if a network case study has two collaborating organisations, therefore at least two critical persons who closely worked together as the main points of contact between organisations will be interviewed. Regarding graph theory, the main points of contact are critical persons within collaborative organisation networks.

If they are removed, there will be no relations, the network will be disconnected. (see more details of a cut point in Section 3.8.3)

3.7.2.2 BEFORE DATA COLLECTION

First, regarding my experience from two pilot studies, the formal approach is the best strategy to access the network case study. In each network case study, the introductory research document attached with the covering letter, (as shown in Appendix C-1) is sent by post to particular persons within the collaborating organisations. The list of contacts is obtained from the previous pilot studies. The introductory research document (as shown in Appendix C-2) includes the following topics:

- ☐ Summary of initial research
- ☐ The research purpose
- ☐ Case study criteria
- ☐ Interview Procedure
- ☐ The reassurances of confidential information treatment
- ☐ Executive summary report

After that, I contacted these persons by telephone (i) to ask their permission to investigate their case studies, (ii) to arrange further appointment to interviews, and (iii) to ask the details of their collaborative partners.

3.7.2.3 DURING DATA COLLECTION

There are two types of data collection methods: by interview and by questionnaire (see more information of each case study report in Chapters 4-7). First, by face-to-face interview, the research participants are visited in their offices at their convenient time. The interview is approximately one hour. With research participants' permission, a tape recorder is used during the interview to assist in writing up afterwards. Small notes were written on the interview script

during interview. Secondly, by adjusted questionnaire from the interview script, with the research participants' agreement, the questionnaire is attached via email. There are some further contacts by telephone conversations or emails if some questionnaire answers need to be clarified.

3.7.2.4 AFTER DATA COLLECTION

After each interview, I transcribed the interview verbatim and filed the transcript according to the categorisation of questions in the data collection tool. The transcript was typically in the form of paragraphs (see the example of transcription in Appendix C-5). On the other hand, all questionnaires are printed out to keep as a record. They were categorised by using the same system as the interview transcript.

3.7.3 DATA COLLECTION TOOLS

Initially, the study plans to investigate all network case studies by structured, face-to-face interviews. However, there are both expected and unexpected circumstances occurring during data collection process (see more information of each case study report in Chapters 4-7). For instance, there are some sensitive issues surrounding a network case study and also some research participants are very busy. Therefore, the study needed to adjust the data collection process. In some cases, all or a part of research questions needed to be sent out by email in a form of questionnaire. As a result, there are two types of data collection tool: (i) structured interview script (as shown in Appendix C-3, Interview Script 1) and (ii) questionnaire (as shown in Appendix C-4, Questionnaire 4). These two types are based on the same design principle and structure.

The data collection tool is designed by employing ten observed issues, ten factors and one hypothesis as guidelines in structuring all data collection questions. (See

the details of the analysis of the measurement of the factors in Table 3-2 in Appendix 3). It comprises three main parts:

Part 1 aims to investigate stories behind each network case study. Open-ended questions are used. It is suggested that 'the open-ended questions allow interviewees to freely and spontaneously express their own views and experiences (Oppenheim, 1992; Coolican, 1999). The research questions in Part 1 are divided into seven topics (please see all research questions of Part 1 in Interview Script 1 in Appendix C-3):

- ☐ Introduction of the collaborative network
- ☐ General arrangement of/during the collaborative networks
- ☐ Collaborative design development process
- ☐ The relationship between the collaborative team
- ☐ In-house team general information
- ☐ Organisation culture and support
- ☐ Problems during the collaborative network

Part 2 aims to investigate critical factors which research participants experienced during collaborative networks and which may not be revealed in my hypothesis. Open-ended questions are used. Part 2 focuses on underlying critical factors in three levels: (i) in the collaborative team across organisation, (ii) within each team and organisation and (iii) between the main points of contact. (Please see the details of three research questions of Part 2 in Interview Script 1 in Appendix C-3)

Part 3 aims to observe how critical the key factors in my hypothesis are and to examine the level of mutuality of each key factor between the collaborative organisations. Part 3 also attempts to identify the effect of each critical factor towards the success of collaborative networks. Close-ended questions, that

answer items are fixed or offered a choice of alternative replies, are used to identify the value of the factors and to measure the qualitative level of mutuality between the collaborative organisations. It is suggested that these questions are normally used to ask about facts, and/or test for current opinion or patterns of behaviour (Oppenheim, 1992; Coolican, 1999). Oppenheim and Coolican suggest that such questions are intended to the consistency of a measure, and being created to a relatively permanent aspect of the individual's cognition and behaviour, such as attitudes, value, beliefs and awareness. Likert-type scale with the total respondent scores of five, ranging from 5 to 1 is used for the measurement technique. Also, at the end of each question, respondents need to give any reason to support their answers. (see the example of all close-ended questions in Part 3 of Interview Script 1 in Appendix C-3)

Please note, the data collection tool in the form of a questionnaire has been developed after the study could not interview or get directly accessed some research participants. Questionnaire is used as part of the data collection tool in Case study 2, 3 and 4 (please view the details of how to use it in Chapters 5-7). Though two types of data collection tool are used the same design principle and structure, there are some difference of question details, especially close-ended questions of Part 3 in Questionnaire 4 (as shown in Appendix C-4) in comparison with Interview Script 1 (as shown in Appendix C-3). The improvements of close-ended questions in Questionnaire 4 are:

(1) The key factors are categorized into three main groups: (a) between the main points of contact, (b) within the collaborative teams or during the collaborative process and (c) within each in-house team and organisation. This aims to increase accuracy of the measurement in each key factor.

(2) The wording of some key factors was adjusted. This helps to reflect the qualitative level of mutuality between the collaborative organisations when one organisation within the collaborative network participates the research instead of all collaborating organisations. As Knoke and Kuklinski (1982, 35) suggest that the approach of all embedded organisations is so crucial for the analysis of the network systems. Knoke et al assert that the consequences of each missing organisation are more severe, because eliminating an organisation also can distort the network systems, structure, behaviour and form. To prevent such missing data, Knoke et al suggest that an organisation should be asked not only about its behaviour, but also other collaborating partners' behaviours. This is because, at least, a portion of the missing organisations' data can be reconstructed from others. Also, this aims to measure a precise issue within some factors. The examples of wording changes are shown in Table 3-3.

(3) Some other key factors were added up, regarding the analysis outcome of Case Studies 1 and 2.

Table 3-3 illustrates the examples of wording changes in some factors of Questionnaire 4 in comparison with Interview Script 1.

Interview Script 1	**Questionnaire 4**
Close interpersonal relationship with your partners' main points of contact	Good interpersonal relationship between the main points of contact
Trust in the abilities of the partners	Trust in the abilities between the main points of contact
Effective communication with your partners' teams	Effective informal communication within the collaborative team across organisations

Before Interview Script 1 has been used, five mock-up interviews were set up within Design Department, Goldsmiths College. These aimed: (1) to examine data collection questions and tool, (2) to check interview duration, and (3) to train my ability to cope with unexpected circumstances during interviews.

3.8 NETWORK CASE STUDY ANALYSIS

The analysis of network case study is divided into two parts: individual network case study analysis and cross-case network case study analysis. First, the individual network case study analysis aims:

- ☐ to describe general information related to the network case study
- ☐ to define critical factors of the network case study
- ☐ to explain reasons underlying each critical factor
- ☐ to define significant issues within each critical factor
- ☐ to evaluate the level of mutuality between the collaborating organisations in each critical factor

Secondly, the cross-case network case study analysis aims to synthesise the research findings of four individual network analysis to answer the main research aims (see Section 1.6).

As Yin (1982) suggests that knowing the analytical strategy and methods before conducting research helps to increase the internal validity and reliability of collecting data. Before approaching each network case study, four main analysis methods are planned to be used for both individual and cross-case network case study analyses: (1) pattern-matching, (2) categorisation (3) data visualisation and interpretation, (4) comparative value.

3.8.1 PATTERN-MATCHING

It is claimed that pattern-matching is a deductive methodology of data analysis and a desirable strategy of case study analysis (Yin 1984). The categories of analysis, 'theoretical patterns' are developed through logical deduction from the pre-existing description, explanation, or theory. In my study, the theoretical patterns (ten key factors and one hypothesis as mentioned in Section 3.6) are pre-defined before the data collection will start. The strategy of this analysis

method is to bring these theoretical patterns to test against collected data. These patterns are used to find/compare an analysed pattern in each network case study with a predicted theoretical pattern or with several alternatives of theoretical patterns. Yin (1984) describes that if the pattern of collected data matches, it will find an explanation and strengthen up the research internal validity. Please note, this strategy is not only used for the analysis method, but also used to shape up the research questions and for making decisions on data sources. Yin claims that to do this helps to strengthen the research reliability.

3.8.2 CATEGORISATION

Categorisation is used to classify collected data into different, relevant units. The relevant units of data, for example a number of words, a sentence, a number of sentences or a complete paragraph is grouped together to create the categories. These categories are in effect labels, guided by the research aims and the emergent structure. This method is mainly used for the summary of the research findings in both individual and cross-case network case study analyses.

3.8.3 DATA VISUALISATION AND INTERPRETATION

It is suggested that data visualisation has been mainly successfully used for the study of attributes and relationships between actors, represented as organisations, persons, or factors within the network (Knoke and Kuklinski, 1982; Schensul et al, 1999). Knoke et al (1982, 38) suggest that 'the well-constructed visual displays of network relations often have a dramatic impact on viewers and can convey an intuitive feel for the structure of a network.'

I decided to adopt data visualisation to use for the interpretation of network case study. I have assumed that it would help to explain, structure and understand relations between collaborating actors (people who worked in the collaborative network), in particular in the issues, such as information sharing, communication

flow, relationship, and working processes. Within each network case study, the following four means of network analysis are applied to examine, as suggested by Knoke et al (1982):

(1) Egocentric network analysis aims to analyse the significant relations of an actor positioned in a center of the network with all other actors.

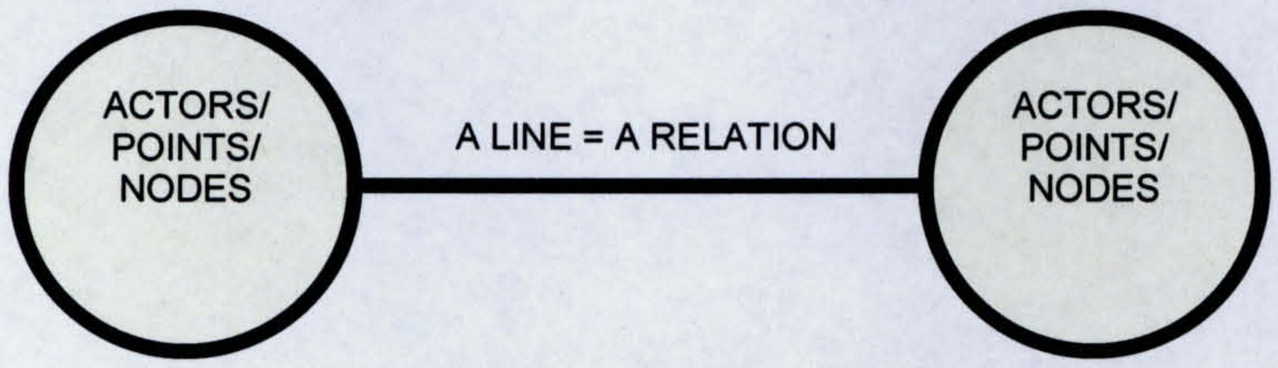
(2) Dyad analysis aims to analyse a pair of actors, 'dyad' in the network. This analysis is used to analyse the relations between two actors.

(3) Triads analysis aims to analyse each possible subset of three actors and their relations, called 'triad'. This analysis is used to analyse the structure of ties among actors.

(4) The whole network analysis is the analysis of the complete network. The complete information about patterning of relations between all actors to establish the existence of distinctive positions or roles within the network is used to interpret and describe the nature of relations between the entire actor positions.

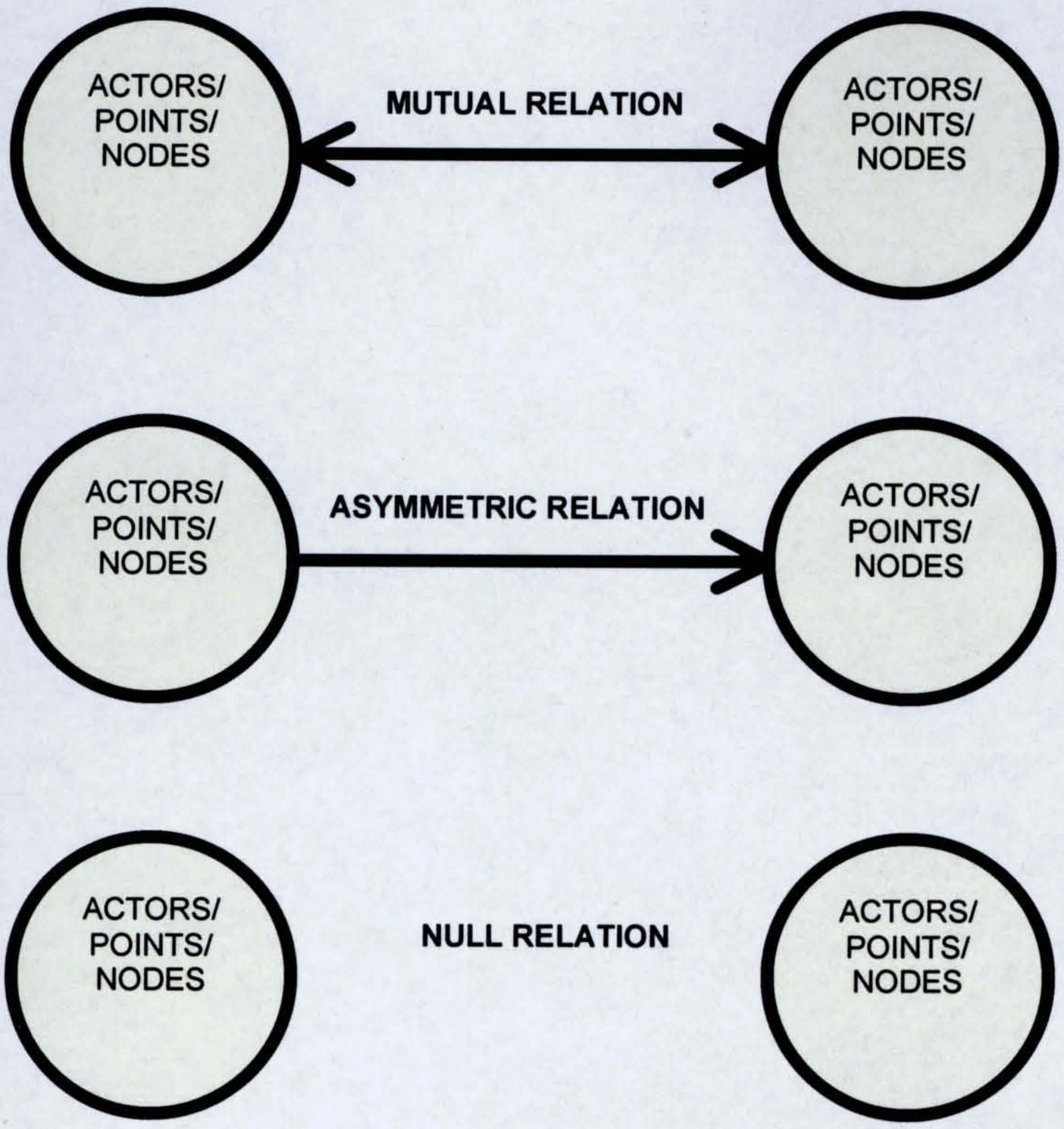
To visualise these four means, two types of visual displays are used: sociogram and digraph. The first type is the technique of 'sociogram' (Moreno, 1934 referred by Knoke et al 1982, 38), the display of a two-dimensional diagram illustrating the relations between the actors in a network. In a sociogram, a set of points represents actors, often labeled by identifying names, letters or numbers. Lines are the set of relations linking actors, drawn between the pairs of the points having no directional connections. The demonstration of the sociogram is shown in Diagram 3-2.

Diagram 3-2 illustrates two significant elements in a sociogram



The second type is the technique of digraph, standing for 'directed graph' (Knoke et al, 1982, 39). A digraph consists of the points linked by a set of directed lines. Arrowheads are used to be the indication of the direction. The direction of arrow emerges from the point/actor initiating the relation and terminates at the point/actor receiving the relation. There are three types of lines/relations in the digraph. First of all, mutual relation is directing lines shown by two-headed arrows linking with both points. Secondly, asymmetric relation is a point/actor directing a line with one-headed arrow toward another. Thirdly, null relation is a relation which no line exists between a pair of points in either direction. Diagram 3-3 illustrates three types of lines/relations.

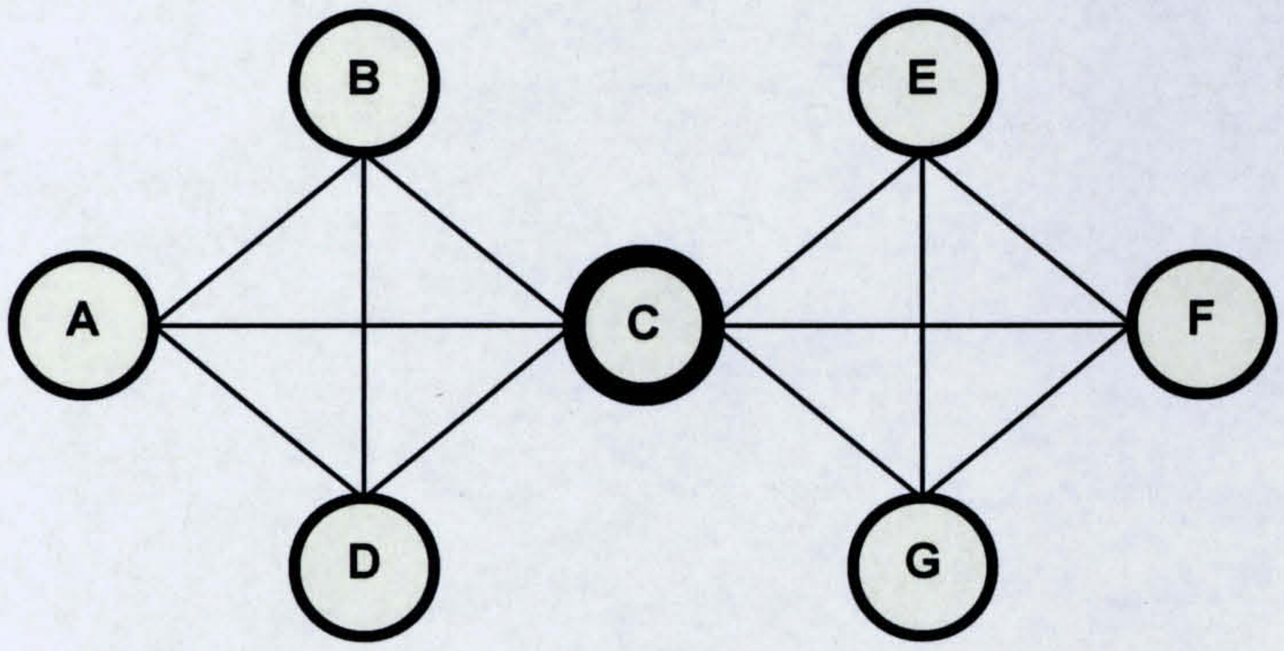
Diagram 3-3 illustrates the three types of lines/relations in a digraph.



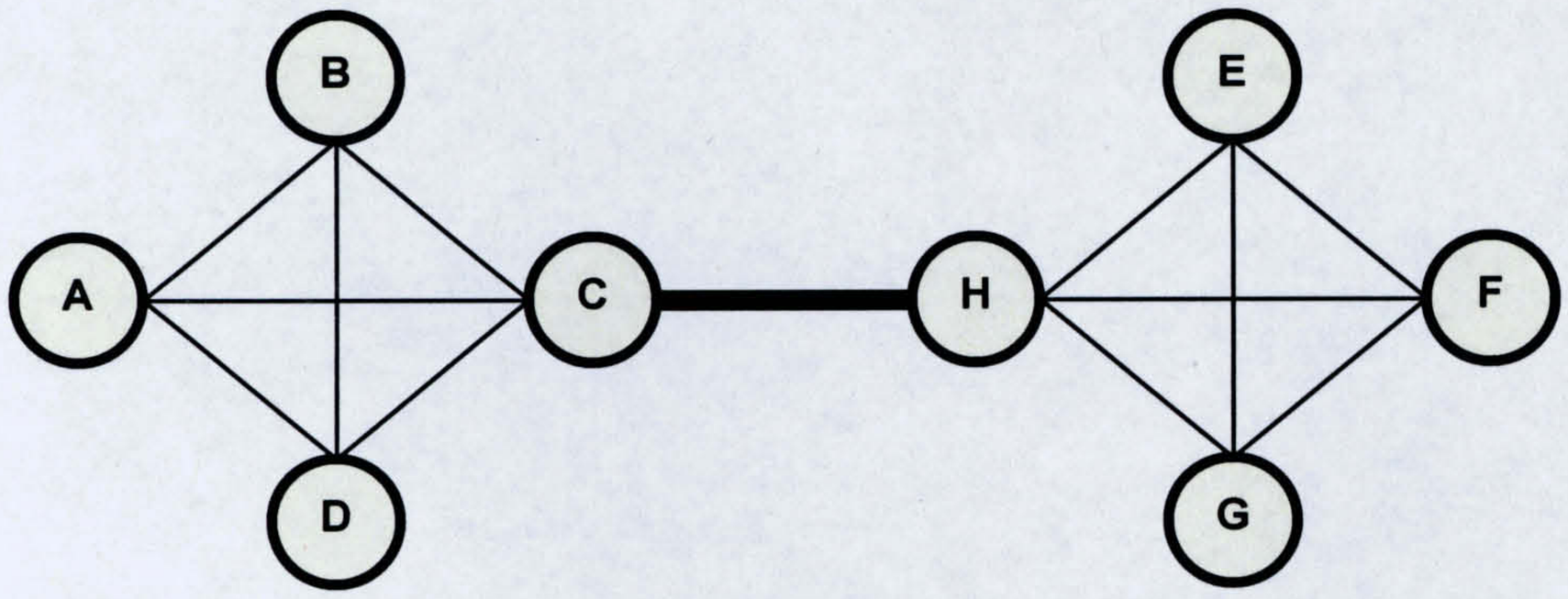
Two particular analytic techniques, suggested by the graph theory applications, are the main focuses: Cut Point and Bridge (Knoke and Kuklinski, 1982). First of all, a cut point is a point/actor removed from the graph that will end up with a disconnected graph. Such cut point presumably plays a brokerage role in the network. The concept of the cut point is used to analyse the significant actors and factors. Secondly, a bridge, a line removed from the graph will delete a single connection between points. If a disconnected graph results, the line represents a bridge between network points/actors. The concept of the bridge will be used to interpret the significant relationships between actors and factors. Diagram 3-4 illustrates the cut point and the bridge.

Diagram 3-4 illustrates (1) a cut point and (2) a bridge in the network system.

(1) The actor C is a cut point.



(2) The line between the actors C and H is a bridge.



3.8.4 COMPARATIVE VALUE

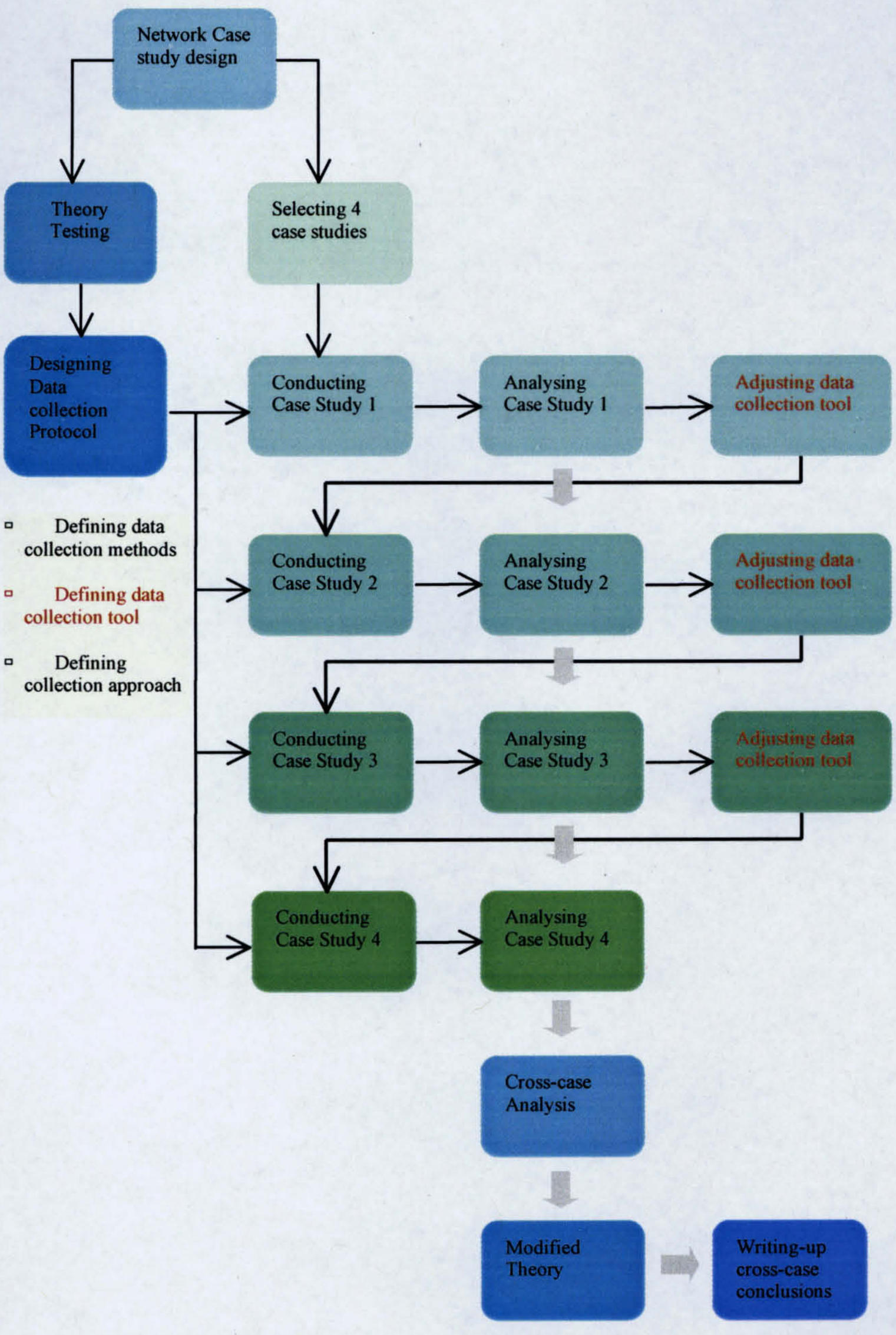
Comparative value is mainly used to analyse the value of each key factor and the level of mutuality between the collaborating organisations in each key factor, particularly in Part 3 of the data collection tool. In each network case study, all collaborating actors/organisations need to identify the quantitative value, ranging from 5 to 1 of each key factor. First, to identify the value of each key factor, its identified values from the collaborating organisations are evaluated. Four value levels are used to evaluate the identified key factor: 4-5 = critical, 3-3.99 =

important, 2-2.99 = little important, and 1-1.99 = Unimportant. Secondly, to identify its level of mutuality, its identified values from the collaborating organisations are compared. If the values are similar, the level of mutuality is completed. If the values are dissimilar, they are calculated to find central tendency, average or mean. Four main categories are used to assess the level of mutuality: high level (the quantitative value 4–5), medium level (3-3.99), low level (2-2.99) and no mutuality (1-1.99).

3.9 NETWORK CASE STUDY PROTOCOL

As Yin suggests in Section 3.4.4, network case study protocol is an essential requirement for multiple case studies in order to increase the reliability. In my study, four network case studies are investigated in sequence. Diagram 3-5 summarises the network case study protocol.

Diagram 3-5 summarises the network case study protocol



3.10 SUMMARY OF FOUR NETWORK CASE STUDIES

During the research planning process, three similar network case studies are selected from the research result of Pilot Study 2 and being sequentially investigated. Unfortunately, during the data collection process of the final Case Study 3, there was an issue of legal contract between the collaborating organisations, which obstructed the study to complete planned data collection regarding the data collection plan (as mentioned in Section 3.7.2.1). After analysing the third network case study, Case Study 4 was therefore inserted to substantiate the research result. Eventually, four network case studies were investigated in this thesis. Table 3-4 summarises the details of four network case studies.

Table 3-4 summarises the details of four network case studies

LISTS	CASE STUDY 1 SILICON GYROSCOPE	CASE STUDY 2 REMOTE CONTROLLED LIGHT	CASE STUDY 3 PROJECT Y	CASE STUDY 4 PROJECT X
1. The nature of collaborative networks in the development of innovative products	Committed collaborative project	Working together	Working together	Committed collaborative project
2. Type of collaborative networks	Cross organisations and expertise	Cross organisations and expertise	Cross organisations and expertise	Cross organisations and expertise
3. Type of innovative products	Radical design-oriented applications	High improvement of existing products	High improvement of existing products	New product to the world
4. Contractual agreement reached during collaborative product development networks	Yes	Yes	Yes	Yes
5. Type of agreement	Collaborative agreement	Consultancy agreement	Technology licensing agreement	Collaborative agreement
6. Contract details	Not permitted to access	Not permitted to access	Not permitted to access	Not permitted to access
7. The outcome of collaborative networks during the period of interview	The manufactured product and on-going product development	The manufactured product	The manufacturing prototype	The manufactured product
7. Time scale of design development process	1997 – currently	May 2001 – August 2002	Nov. 03 – Jan 04	2001-2002
8. A number of the collaborating organisations in the network	2 Nottingham BAE Systems	2 Remote CL Cambridge DP	2 Org. A Org. B	3 Org. A Org. B Org. C
9. A number of the approached collaborating organisations	2	2	1 (Org. A)	1 (Org. A)
10. A number of the research participants	3 Persons: 2 main points of contact and 1 senior manager	3 Persons: 2 main points of contact and 1 senior directors	1 Person: A main point of contact/ company director (Not permission to access the rest)	1 Person: A main point of contact (Not permission to access the rest)
Remark	Anonymous	Joe Ruston Mike Beadman X	Anonymous	Anonymous
11. Data collection approach	Interview	Interview and Questionnaire	Interview and Questionnaire	Questionnaire
12. How the collaborative networks was	Perfect	Run smoothly (problems in product)	Run smoothly	Problematic

3.11 CONCLUSION

Chapter 3 reports research methodology used for the investigation of the existing network case studies. I decided to adopt the research methodology from case study research and social network analysis. Multiple similar case studies are investigated. I suggest that to understand the underlying critical factors of relations within collaborative networks of multidisciplinary organisations in the successful development of innovative products, all collaborating organisations are examined. Regarding the data collection plan, at least persons who worked as the main point of contact during collaborative networks are contacted and interviewed. I have assumed that ten main issues, leading to ten key factors and one hypothesis, would be critical factors for the success of collaborative networks of multidisciplinary organisations. The chosen factors that underpin my hypothesis are:

- ☐ Adaptability between organisations
- ☐ Commitment to the collaborative product development
- ☐ Effective communication process
- ☐ Well-organised collaborative product development process
- ☐ Open information exchange
- ☐ Close interpersonal relationship
- ☐ The autonomy of innovative abilities of each organisation
- ☐ Joint problem-solving
- ☐ Joint decision-making
- ☐ Trust in the abilities of the collaborative organisations
- ☐ Hypothesis: each critical factor should have 'high level' of mutuality between the collaborative organisations

APPENDIX 3

Table 3-2 illustrates the analysis of key factors and their measurements

Key Factors	Description	Measurements of Key Factors	Data Collection Methods
1. Trust in the abilities of collaborative partners	Trust of collaborative partners' abilities during a collaborative project in the successful development of innovative products	1.1 Realising/understanding potential abilities of each other 1.2 The openness about abilities to each other 1.3 Abilities to share responsibilities 1.4 Abilities to listen (e.g. open dialogue and open discussion)	Structured interview with open-ended questions mixed with close-ended questions
2. Good personal relationship	The establishment of relationships between the main co-ordinators who act as an interface between collaborative organisations	2.1 Type of relationships (e.g. professional or friendship) 2.2 The way of building up personal relationship 2.3 Frequency of contact 2.4 The means of contact 2.5 How deeply co-ordinators know each other	Structured interview with open-ended questions mixed with close-ended questions
3. Open information exchange	The openness of information and the means by which information is exchanged	3.1 Sharing internal sensitive information (e.g. technical knowledge, tacit knowledge, etc.) 3.2 Sharing the changing external information that innovative products need 3.3 The quality of feedback about innovative products 3.4 The content of exchanged information 3.5 The frequency of exchanged information	Structured interview with open-ended questions mixed with close-ended questions
4. Joint problem solving	Problems involving innovative products within collaborative projects have been jointly solved by collaborative partners.	4.1 Brainstorming section together 4.2 Identifying the process of brainstorming 4.3 The arrangement of particular joint activities on new product problem solving (What is it? and How does it work?)	Structured interview with open-ended questions
5. Joint decision-making	Decision-making involving innovative products within collaborative projects has been jointly determined by collaborative partners	5.1 The method of decision-making in evaluating product performance 5.2 The way of decision-making in evaluating project performance 5.3 The way of decision-making during brainstorming sessions 5.4 The decision-making process	Structured interview with open-ended questions mixed with close-ended questions

Key Factors (Continued)	Description	Measurements of Key Factors	Data Collection Methods
6. Commitment to innovative product projects	The strength (intensity) of collaborative organisations in supporting innovative product projects	6.1 The types of support (e.g. extra money, activities or manpower) 6.2 The methods of support (e.g. the range of staff) 6.3 The levels of support (e.g. the management involved) 6.4 The way of communicating information	Structured interview with open-ended questions mixed with close-ended questions
7. Well-organised collaborative product development process	During the development of innovative products, the collaborative process has been well-planned.	7.1 Identifying each stage within the collaborative process for innovative products 7.2 Identifying clear objectives of collaborative project needs	Structured interview with open-ended questions (the review of documents if possible)
8. Open communication both formally and informally	Communication flow within the collaborative network for innovative product projects.	8.1 The means of communication between collaborative organisations, both formally and informally (How many of them) 8.2 Frequency of communication both formally and informally 8.3 The route/direction through which information has been distributed/has flowed, both formally and informally 8.4 The openness of information	Structured interview with open-ended questions
9. The autonomy of innovative abilities	The independent abilities of collaborative partners in order to innovate	9.1 Innovative/creative culture 9.2 Innovative/creative environment 9.3 Organisational philosophy of innovation/creativity 9.4 Internal communication within organisations about product innovation	Structured interview with open-ended questions and The review of documents
10. Mutual working system adaptation	The reciprocal adjustment of collaborative organisations when working together on innovative product projects	10.1 The negotiation of working system 10.2 Conflict solving during innovative product development 10.3 The flexibility of working system 10.4 The perceived quality of working systems	Structured interview with open-ended questions mixed with close-ended questions

CHAPTER 4: CASE STUDY 1

THE COLLABORATIVE NETWORK BETWEEN BAE SYSTEMS AND NOTTINGHAM UNIVERSITY IN THE DEVELOPMENT OF THE SILICON GYROSCOPE

INTRODUCTION TO CHAPTER 4

Chapter 3 reports two pilot studies and summarises the network case study methodology. Chapter 3 also identifies ten key factors and one hypothesis which will be verified through four existing network case studies, collaborative networks of multidisciplinary organisations in the development of innovative products.

Chapter 4 describes the investigation of Case Study 1: a successful collaborative network between BAE Systems and Nottingham University in the development of the Silicon Gyroscope. The following sections are:

Section 4.1 describes general details of Case Study 1.

Section 4.2 details the research approach of Case Study 1.

Section 4.3 describes the background information of Case Study 1, including the product specification of the Silicon Gyroscope, backgrounds of the collaborative organisations, background of the collaborative team, and background of the collaborative network.

Section 4.4 describes the analysis of the research questions in Part 1 of the Interview Script 1, focusing on the detailed story of Case Study 1. The main topics of the analysis are: the arrangement of the collaborative network, the arrangement of the collaborative team, collaborative product development process, communication, information exchange, relationship, adaptability, Top Management support, innovation culture, and problems/conflicts during the collaborative network. Section 4.4 also summarises the research findings and reflects significant points derived from the research questions in Part 1.

Section 4.5 describes the analysis of the open-ended research questions in Part 2 of Interview Script 1, focusing on the identification of critical factors. The analysis of critical factors is divided into three main categories: critical factors within the collaborative network, critical factors within each team/organisation, and critical factors between the main points of contact.

Section 4.6 describes the analysis of the close-ended research questions in Part 3 of Interview Script 1, focusing on the assessment of how critical key factors in my hypothesis are and the level of mutuality of each key factor.

Section 4.7 summarises critical factors derived from the research findings of Case Study 1

4.1 INTRODUCTION

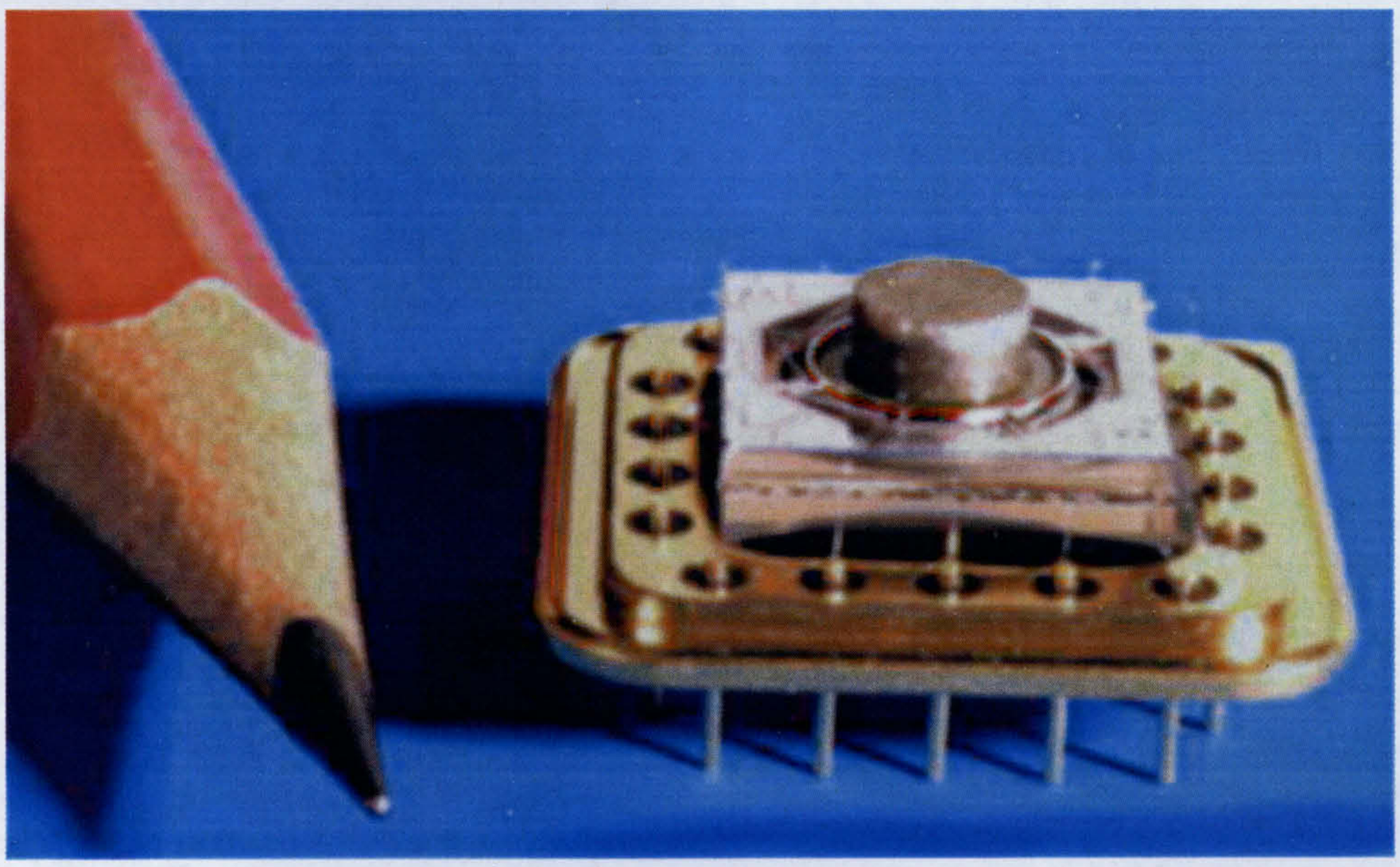
The Silicon Gyroscope was one of the winning products from the UK Millennium Product Awards. This collaboration has been chosen from the publication of the UK Design Council in 2001, 'Meeting of Minds.' The product was successfully developed by the collaborative network between BAE Systems (Plymouth) (BAE) and Nottingham University (Nottingham).

4.2 RESEARCH APPROACH

The Network Case Study information was based partly on investigation based on information given by three interviewees: CF and GO worked for BAE, and DR worked for Nottingham. These persons were interviewed in structured face-to-face conditions. Please see Interview Script 1 in Appendix C-3 and the details of the interview script design in Section 3.7.3.

4.3 BACKGROUND OF CASE STUDY

4.3.1 BACKGROUND OF THE SILICON GYROSCOPE



Picture 4-1 illustrates micro-mechanical silicon ring gyroscope

The UK Design Council (2002) claimed that the Silicon Gyroscope (SG), as shown in Picture 4-1, was the world's first micro-mechanical silicon ring gyroscope. Previously gyroscopes had been used purely for the stabilisation and guidance of ships, aeroplanes, spacecraft and missiles. However, the problem of gyro technology in everyday applications was its prohibitive cost and size. The SG was developed in response to these problems. The advantage is that unlike the classic gyroscope the SG has no spinning parts. It works by using the Coriolis Effect. This effect, caused by the rotation of the Earth, is what makes water always spin in the same direction when going down a plug hole. The SG worked by vibrating tiny silicon rings. The vibration pattern makes the ring first change into a rugby ball shape, then back to football shape and into a rugby ball shape again, and so on, at 14,000 times a second. Electrical signals can be generated by using a very small magnet in the middle of the ring and microscopic conductors printed on the surface of the ring. The SG is used for the advanced braking systems, to help the driver to regain control of the car. For example, if a gyro is fitted to a car which is stationary, then there is no signal coming from the vibrating ring. If the car is moving and goes into a skid, the gyro rotates and a signal is generated in the vibrating ring due to the Coriolis Effect.

The original market of gyro-based product was more focused on high performance than cost. More recently, partly due to high competition in the market, this product has needed to be critically focused with both good performance and reasonable cost. The SG has two main markets: the automotive industry/customer and aerospace and military industry/customer.

4.3.2 BACKGROUND OF THE COLLABORATIVE ORGANISATIONS

Two organisations collaborated in this collaborative network:

4.3.2.1 BAE SYSTEMS (PLYMOUTH) is part of the UK BAE Systems. It specialises in researching, developing and manufacturing Gyro-based products. It has an in-house research, design and development (RDD) team working on Gyro-based products and products based on navigation. The team works under the Technical Director of the UK BAE Systems. It does not work for one particular business because Gyro-based products actually feed into a number of business areas. Three main teams work under the Technical Director, who decides what products need to be researched. First, Core Blue Sky Research Team looks at future products. Secondly, the Product Development Team develops existing products. Thirdly, the Product Supportive Team provides data and information to support other businesses that use the product. These three groups work together in the same space as an 'Integrated Product Team'. The Integrated Product Team comprises three main disciplines: physicists, electrical engineers and mechanical engineers. This team aims to improve the performance of existing Gyro-based products. The team's main duty is to introduce methods to improve performance and cost efficiency of the products to ensure a competitive place in the market.

Before starting the collaborative project with Nottingham, BAE Systems (Plymouths) worked with at least three British Universities. Before contacting each University, the Company will define what it needs to resolve. Then it will go through a selection process to ascertain which Universities have skills and knowledge required. There are two sources from where the Company can select the qualified University. First, the local University has been recommended in Plymouth. The second is the lists of co-operated works of Universities that are approved by the Company. In the case of collaboration with Nottingham, the selection process was out of two available sources. The company selected

Nottingham because the University has an in-house expert who could deliver what the company required. CF, a member of the operational level in the RDD team, mentioned the reasons that the company did not have experience in dynamic mechanical engineering to deal with particular problems of the development of the Gyro-based product, and this is beyond the company's core skills. Also, it does not want the specialist all the time. CF commented further that this collaboration is very much on needs.

4.3.2.2 THE SCHOOL OF MECHANICAL, MATERIALS, MANUFACTURING, ENGINEERING AND MANAGEMENT is part of the UK Nottingham University. One of the School specialties is the Gyroscope field. As mentioned by The Design Council (2001), it has been working in this field since 1970.

4.3.3 BACKGROUND OF THE COLLABORATIVE TEAM

The collaborative team comprises two main teams as follows:

4.3.3.1 The RDD team is BAE's in-house team and mainly works on the research, design and development of Gyro-based products. For this project, the RDD team was responsible for the identification of problems, and the inspiration and aspiration of the SG. Most of problems or issues were related to BAE's customers, both intermediarists and Automotive Industry requirements. Some were defined within the RDD team. CF worked on the operational level. GO worked on the managerial level.

4.3.3.2 The NOT Team is Nottingham team. This team comprised DR and postgraduate students. For this project, the NOT team was responsible for the basic background research of problems which would be used to assess the development of innovative products in the future. Particularly, it contributed to the research and development of the SG mechanical applications, including

contributing general theoretical works about material and device behaviours and specific package works for solving specific technological problems. DR worked on both operational and managerial levels.

4.3.4 BACKGROUND OF THE COLLABORATIVE NETWORK

BAE Systems (Plymouth) started working with Nottingham University in 1994. Before the collaborative network started, it was a small subcontractual project which involved a specific design problem of the Silicon Gyroscope (SG) during the early stage of its development process. The problem was the balancing of the gyro moulds; the distribution of mass and shape of the ring affects the symmetry. As GO mentioned, 'if the gyro is not well balanced, it has a bias.' This problem causes the SG to perform poorly. BAE identified key design steps to reduce this problematic error: (1) making the ring accurately in the first place, (2) being able to trim the ring using a laser to remove material, and (3) understanding how and where to fire the laser. According to these, BAE needed an expert in 'dynamic mechanical engineering'. BAE needed to look for a specialised external organisation because it did not have in-house expertise and the problem was beyond its in-house core skills.

There are two alternatives that BAE could have used to solve these design problems: either the company could have employed the specialist expert required to work with the in-house research team, or the company could have worked with an external expert. BAE believed, as CF stated, that it is better if the company has all the capabilities internally because the company can control of the resources and does not need to spend money outside. However, the company decided to find a sub-contractor with external experts. CF commented on this decision that 'it is very much special case…. For this sort of collaboration, certainly in my experiences it is very much on needs.' This is because BAE did not want to employ the specific expertise to work within the RDD team. It was afraid

that after solving the problems, the company would not need or have a job for the specialist to continue working in the team.

Before BAE decided to collaborate with Nottingham, it searched for external specialised experts in journals, such as written papers and other public domain documents. There were many specialists around the world with whom the company could work. It was thought, as CF mentioned that it is an advantage for the company to have an external specialist as geographically close as possible. As a result, the company decided to search for a sub-contractor within the UK. The company decided to choose Nottingham because of the expertise of DR. CF approached DR and described a problem that BAE experienced. BAE needed DR to help on the small package of consultancy work, the analysis of trimming problem. The collaborative network has started since finishing this initial consultancy project. This collaboration has continued to the end of 2003. There are a series of projects which BAE and Nottingham have jointly collaborated and agreed to continue, focusing on the basic research to improve the performance of the SG. In addition, for the whole development process of the SG, BAE worked with other external specialised organisations, including a joint venture with Sumitomo Precision Products (Japan), and the manufacturing partnership with Silicon Sensing Systems. Please note, this study mainly focuses on the collaborative network between BAE and Nottingham.

4.4 ANALYSIS 1: STORY OF THE CO-NETWORK

The following sections result from the analysis of the research questions in Part 1 of Interview Script 1.

4.4.1 THE ARRANGEMENT OF THE COLLABORATIVE NETWORK

4.4.1.1 THE MANAGEMENT OF THE CO-NETWORK

CF had been in charge of the management of all BAE's collaborative projects. The projects were monitored by GO and BAE Top Management. To understand the successful management of the collaborative network, the study employs BAE's research information, especially CF's viewpoint as core evidence. CF worked as a critical interface between internal and external teams. The strategy that CF managed collaborative projects was divided into two parts: (1) the legal part and (2) the working part. CF mentioned that 'the way it works is ideal very much... We try to do it informally to work together as colleagues and equals. And I am very much trying to keep that quite separate from the legal side.'

First, the legal part mainly involved the contractual agreement which had been set up by legal administrators from both parties within the legal boundaries. In this agreement, terms and conditions had been formally and jointly agreed by both parties. Three fundamental conditions are mentioned during the interview, including the payments, the intellectual property rights (IPR) condition, and the working condition. The legal document had a significant influence on the working part. It helps both parties to be less worried about benefits and to be able to work openly and informally. As CF pointed out that

"So we set up the terms and conditions. Both parties sign up for that. And then that loses myself and [DR] to just concentrate on natural business of working together. Once all the legality is set up we can do that in a very open and

informal way, which is the easiest way to actually get the work done really. You don't want to be in combat with a lot of processes or any formal management."

Moreover, if there were any contractual disputes, CF would try to sort them out without getting involved.

Secondly, the working part involved how both parties worked together effectively and successfully. CF believed in 'informality' and preferred to work with the external partner as 'colleagues and equals'. As mentioned above, on the one hand, the informality helped the working team struggle less with a lot of processes or any formal management which may discourage the collaboration. On the other hand, the notion of colleagues and equals helped the external partner to feel part of the CF's team. CF commented that this idea had actually worked well for the external partner and the collaborative project. As a result, as mentioned CF the external partner is 'obviously more motivated' and both parties can 'get more out of the project'.

4.4.1.2 THE ARRANAGEMENT OF THE COLLABORATIVE TEAM

As mentioned in Section 4.3.4, the whole process of the gyro-based product development has been mainly managed by the core RDD team. This RDD team had close connections with both in-house teams and external organisations. For an in-house team, the RDD team linked with Bath Technology Centre and Bristol Research Centre. For external organisations, the RDD team collaborated with Nottingham. Nottingham became a virtual part of the RDD team as a whole as shown in Diagram 4-1. The collaborative multidisciplinary development team comprised both internal and external expertise, as shown in Diagram 4-2. Within the internal RDD team, there were three core disciplines: electronic engineers,

physicists and mechanical engineers. For the NOT team, it specialised in mechanical dynamic engineering.

Diagram 4-1 depicts an overview of both internal and external connections of the RDD team in the development of SG.

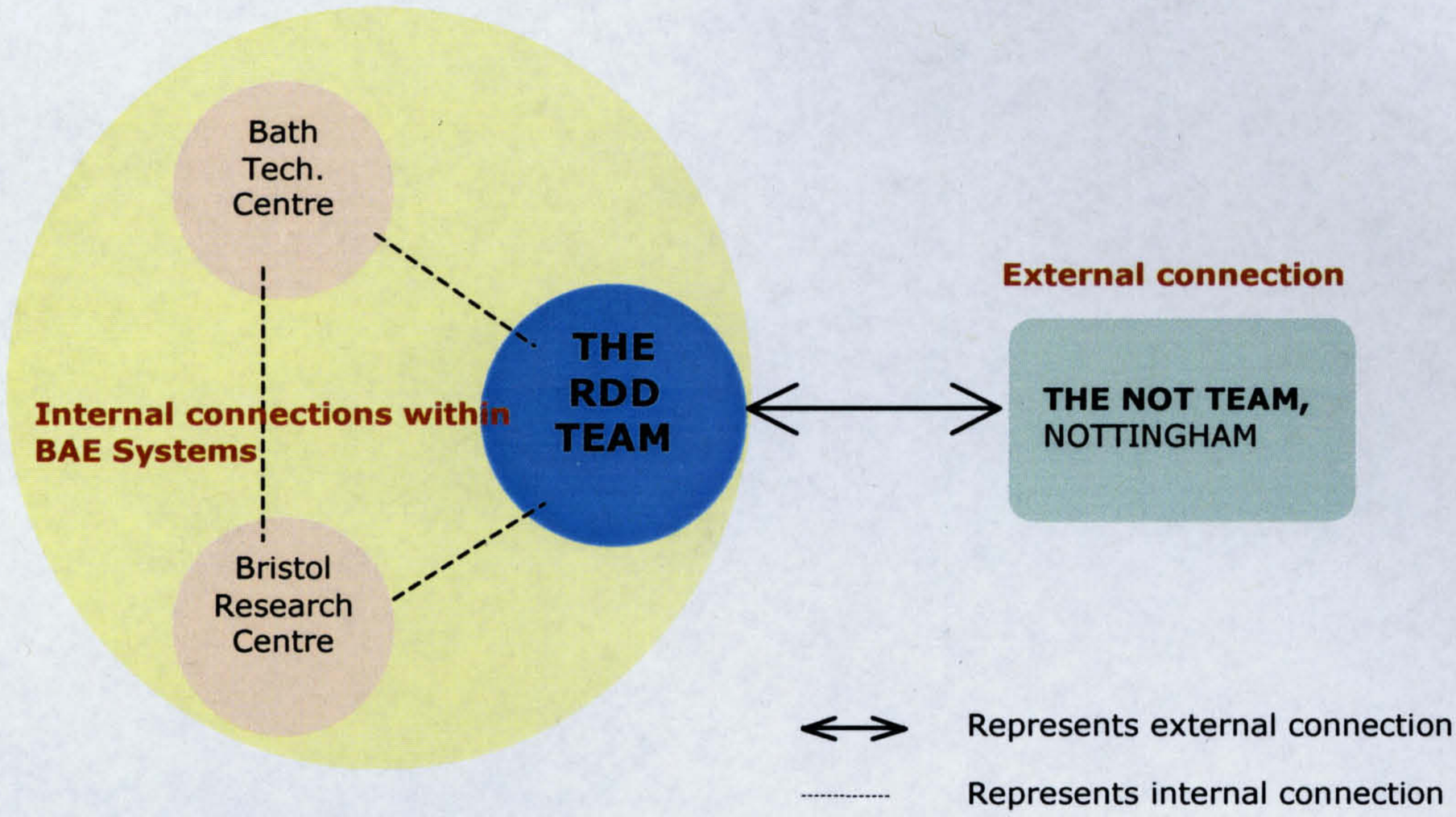
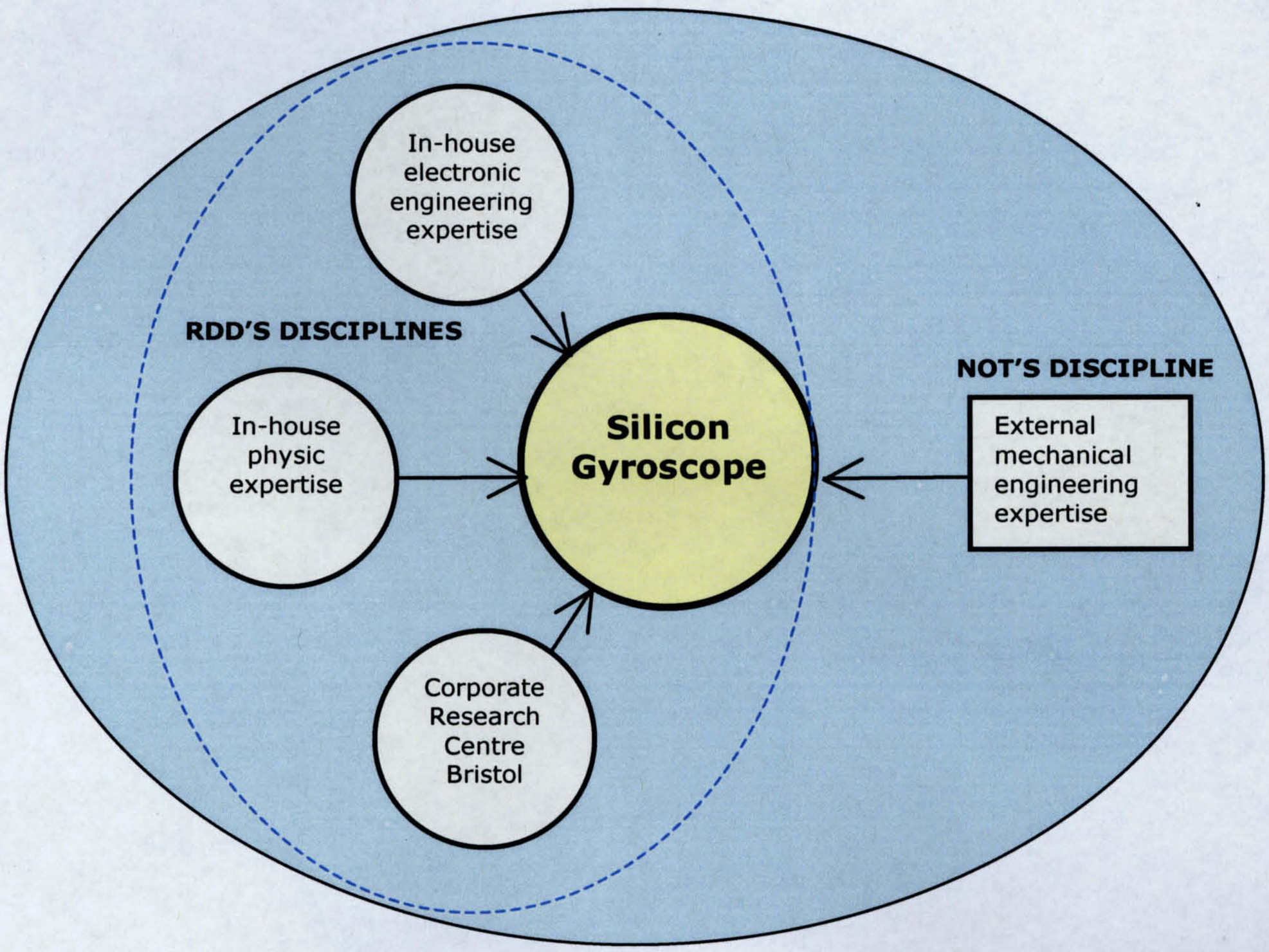


Diagram 4-2 depicts the collaborative multidisciplinary development team in the development of the SG.



4.4.2 COLLABORATIVE PRODUCT DEVELOPMENT PROCESS

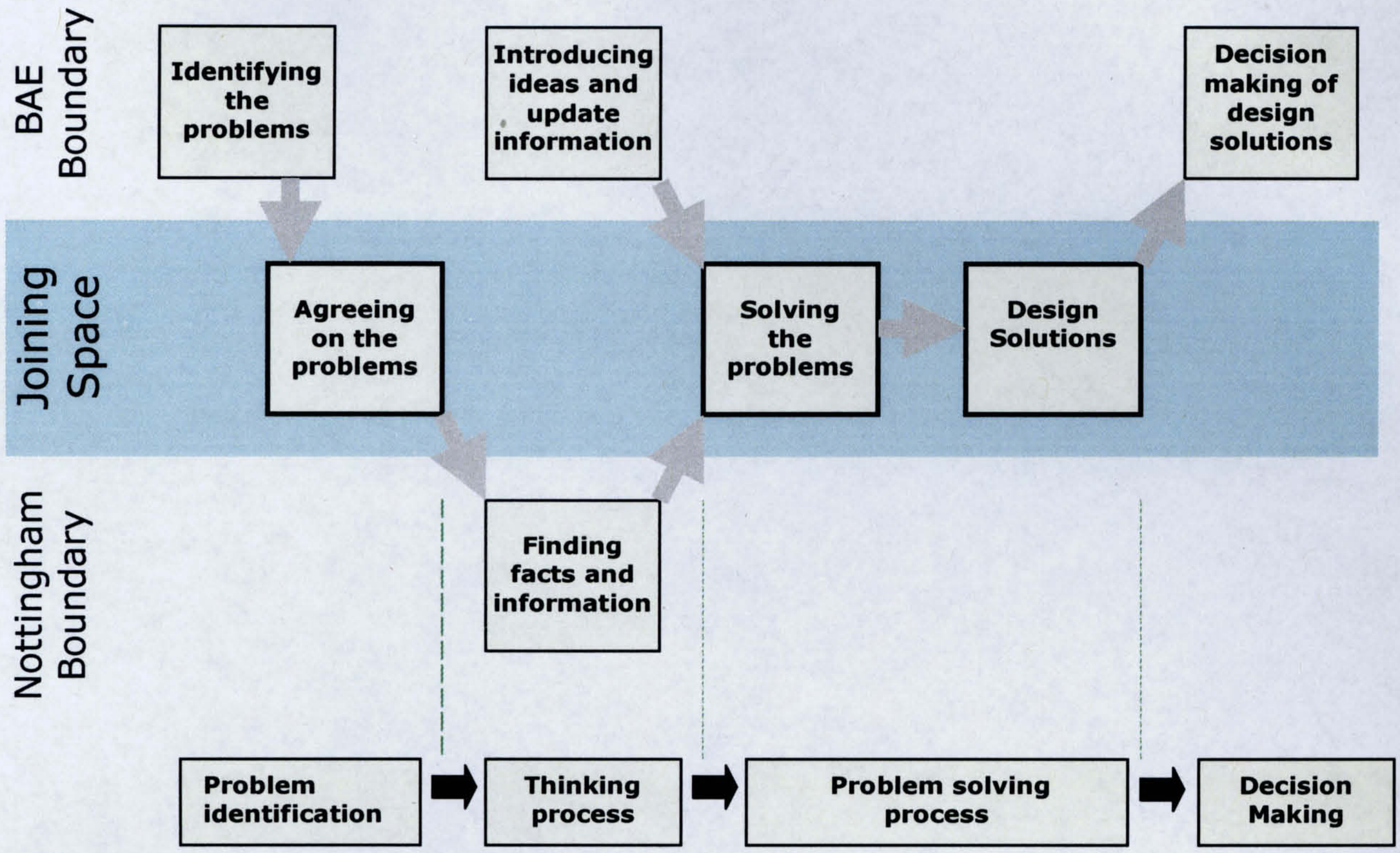
The entire collaborative product development process of the SG consists of two main parts. Firstly, most of the large-scale jobs in this process, such as improving new manufacturing process and producing new products took place within BAE. Most of the inductive jobs, such as a new way of balancing the Gyroscope in the micro level, and how to improve particular applications, were based on the collaboration with the RDD team.

Focusing on the collaborative product development process between BAE and Nottingham, as shown in Diagram 4-3, the study depicts the co-development process in four stages: problem identification, thinking process, problem-solving process and decision-making.

(1) Problem Identification

The brief of problems, as shown in the stage of Problem Identification was mandated by BAE's marketing and business people. These people discussed with the main customers, regarding their requirements. CF mentioned that normally, 'customers always want new product applications that are better and cheaper and they always want them now.' CF suggested that 'better and cheaper' could mean, 'smaller, more accurate and consuming less power.' Also, some briefs were defined by the RDD team. If the problems were defined by the RDD team, CF needed to give a proposal to persuade Top Management for funding. This proposal had to be a business case which would be one of the BAE's business needs. CF mentioned that the research project needed to be very focused and mostly was 'application-oriented'.

Diagram 4-3 depicts the collaborative product development process between BAE and NOT



(2) Thinking Process

Before any collaborative projects could be started, CF brought the brief of problems potentially suitable for the expertise of the NOT team to discuss with DR, to ensure that the NOT team could help or do the job. If mutually agreed, the collaborative project would be taken on. CF required the NOT team to find facts and information which were significantly related to new applications of innovative products, such as the flexibility, the stresses, the effectiveness and the strengths. Once all facts and information had been investigated, by the NOT team, DR would either take on the research or introduce one of DR's research students to do it. CF and DR jointly discussed about how to solve the problems.

(3) Problem-solving Process

Both teams jointly discussed on how to solve the problems and decided the best solutions for them. DR mentioned that during the problem-solving process, '...we do it by identifying jointly'; individual ideas were pooled and shared, and 'agreeing on the best way forward'. DR shared any information and facts which were updated to CF and vice versa. DR was kept informed about what the RDD team had been doing and what problems the team had. Face-to-face meeting was arranged, at least 2 times per year.

Along this process, if both parties agreed what the expected solution of the problem would be, this solution would be tested. However, CF added that though we both agreed in the solution, 'we still did not have a good way of solving some of the specific issues that we were dealing with... We are very much like-minded ... [and] both aware of the problem... When it is solved, we both know.'

(4) Decision-making

As mentioned above, if the decision-making regarding the best problem solution was during this process, both parties were agreed on the best way forward. However, the decision-making concerning converting the problem solution to marketable innovative products would be the responsibility of BAE. This is because several risky accounts need to be considered, such as constraints of technical works, investment and the decision-making from other internal business parties, such as marketing and business people. As DR and GO mentioned, DR, (as the virtual part of the RDD team), has a right to recommend or suggest which problem solutions would be the best for

innovative products. At the end, DR will play no part in any decision-making concerning marketable innovative products.

4.4.2.1 THE MANAGEMENT OF THIS PROCESS

This process is informal and reasonably flexible. CF mentioned that generally it was not a regular or routine process because the NOT team could be required helping in any unexpected circumstances. For instance, when CF had small problems which needed some very quick help, these problems could be accommodated within the set up. As CF pointed out the flexibility of this process helps to sustain long-term project that, 'because it is flexible ... we can have this long-term project.' CF also referred to this process that 'I do not have long-term plan for the actual content of the work.' The plan was adjusted as on-going research moved along. From the BAE viewpoint, two main reasons are indicated. First, the RDD team would not know what would happen in the future. For instance, as mentioned CF, '...maybe in five years time, we have a very mature product and we do not need to do a research on [SG]…. There is no longer requirement.' Secondly, because of the nature of the research itself, during the research, there might have been a whole load of new problems needing new solutions. CF asserted that

"...because one of the good things about the research is you don't know the answer to the question. Generally, what happens is when you explore one thing; you suddenly see when you get to this…. There are a whole load of new problems, so then you come up with the idea. But you can't plan to see ahead that far. ...There is no real long-term plan. I think we are looking maybe for two years time scale."

4.4.3 COMMUNICATION

During the collaborative network, both informal and formal communications had been arranged within the collaborative team. First, quite frequently for the informal communication, the team contacted each other by telephone, mainly between CF and DR. Also, there were email contacts between both team members. Secondly, significant information, such as research findings was communicated via formal communication. Normally, the arrangement of the formal communication - face-to-face meetings had been done flexibly on a particular need basis. From the DR viewpoint, the necessity based meeting was better than regular meetings. DR pointed that, 'that is a good discipline really, [the team] do not just have meetings for the sake of it.' Moreover, the NOT team did not need to provide a report every three or six months which was really time-consuming and distracting. The team would report when was necessary. From the BAE viewpoint, CF mentioned 'we generally try to have meetings every 2 or 3 months.' CF preferred close contact and communication with the NOT team but, because of his time constraints and the pressures from his routine works, he could not do it frequently. One official meeting was arranged each year at Nottingham. This was a whole day meeting in which the NOT team members presented their progressive works to CF and his team members. Afterwards, the collaborative team had discussions about those works. As CF mentioned, 'it is a chance to do in more formal and thorough way...'. GO added further management viewpoint on communication that the importance of communication is not only the methods, but also the mutual understanding about the requirement of the collaboration. GO pointed out that the important thing is the beginning of every piece of work. It needs the same discipline of making sure that the team across organisations understands exactly what is required. There is no misunderstanding because almost all of the relationship difficulties caused by misunderstanding.

Conclusively, CF and DR both agreed that the arrangement of both informal and formal communication had no problems at all during the time of the collaborative network. As DR mentioned, 'no, as I said before it sounds good to be true but, really, no.' CF mentioned that the combination of both informal and formal routes of communication 'certainly works very well'. From the management viewpoint, GO gave determinate factor that there is no problem of communication during the collaboration because of mutual understanding of both parties on the requirement of collaboration. GO asserted that the key success of communication is actually down to the ability of the people.

4.4.4 INFORMATION EXCHANGE

Based on the contractual agreement of the collaborative projects, the NOT team needed to sign a formal, legal agreement, called 'Non-Disclosure Agreement'. Fundamentally, every piece of information received from BAE has commercial sensitivity. The NOT team is not allowed to pass on, talk about, share, and/or discuss any information involving the collaborative project to other people without permission.

During the collaborative network, the evidence suggests that both parties agreed on their open information sharing. From the BAE viewpoint, as mentioned CF, CF was very open regarding sharing information involving the product, 'particularly the technical side, we keep inform [DR] as much as we can'. Similarly, GO pointed that on the technical front, the company is very open on sharing information to DR. The company will open information that DR needs to know. Nonetheless, the company had very few secrets. GO emphasised that it is 'not any deliberate things' because DR would not be interested in other technical fronts, such as electronics or the market side in the great detail. DR knows what is going on about the company customers and market, but it is only rough information. From the DR viewpoint, because BAE funded the research, the

company had the full right to know everything that came up from the research, but DR does not have the right to know everything in the company. Furthermore, mentioned DR, we share a lot of information, such as the details of the product problems, what current the team were finding and doing and the current thinking on the particular issues.

Turning to the point of motives of information exchange, the evidence suggests that its motives are different for each party. From the BAE viewpoint, trust at a personal level, and the set-up of the collaborative activity, underpin open information exchange. Mainly, as CF mentioned, CF does not believe in Non-Disclosure Agreements related to how BAE openly shares sensitive information. CF believed that 'it is a mutual trust.' Moreover, as CF mentioned, we trust DR and have complete faith in his integrity. Furthermore, GO added that we worked with DR for a long time and some of DR's research students had industrial secondment, intentionally set up, within the company for a period of time. So we would find very difficult to hide anything from each other'. GO remarked '...if we would not have [openly information sharing], it would make [the collaboration] really difficult.' From the DR viewpoint, a Non-Disclosure Agreement strengthens information exchange. As DR mentioned, DR supposed that the partner shared sensitive information to the NOT team because the confidential agreement that both signed and agreed.

4.4.5 RELATIONSHIP

As mentioned before, during the collaboration, CF and DR were the major interface between both teams across organisations. Other collaborating team members had not participated together that much, about a couple of weeks per year. Therefore, the relationship between the collaborating teams will be examined through CF and DR.

From the CF viewpoint, the individual person is critical for all relationships. As mentioned CF, 'it depends on personality really in all relationships about individuals. ...whatever the process is, it will come down to the personality in the end in any process.'

CF mentioned that there was no problem or conflict during the collaboration because of DR's personality which is referred to as a combination of two attributes: personal attitudes and skills. CF described the former that DR is 'a very nice person and very easy-going and I have got a lot of respect for him.' Regarding DR's skills, DR has a professional background in industry so he has very good communication skills and very good characteristics –to actually provide a good service, and he is very responsive. CF contrasted DR's skills with typical academia who he had experienced; that they are not always socially gifted, sometimes are a little bit arrogant, and think they know better. Regarding CF's personality, DR did not refer to it. However, DR pointed to the significance of building a good relationship on a personal level.

CF and DR agreed that the development of a good relationship on the personal level, or towards friendship, is significant. CF believed that personal relationships help people to work together easier, especially if you actually like the people on a personal level, and because of mutual respect. CF mentioned that he regarded DR as a friend and pointed out, that 'because we get on very well so we have been working together 7 or 8 years now.' From the DR viewpoint, DR also believed that a good relationship on the personal level, which is not recognised as much as it should be, is perhaps the most important and the basis of all successful work. DR gave the example of having a meal or a drink informally together after a meeting as part of hospitality which is more than just strictly professional relationship. DR further remarked that 'it has always been like that with different people'. However CF and DR agreed that if a relationship does not work well on the personal level,

one can still find a way of working together; but they believed that friendship in the relationship is supportive to a great extent.

4.4.6 ADAPTABILITY

On the team level, from the BAE viewpoint, CF mentioned that there is no need for the RDD team to adjust themselves to the NOT team for several reasons. First, the RDD team belongs to the large organisation which had its long-established norm and process. Secondly, the NOT team works as a virtual part of the RDD team. Even though, in every year, some of the NOT team members have a work placement within the RDD team for a few weeks and the RDD team needs to look after them, it is generally not a problem because their working backgrounds are similar. Thirdly, the main points of contact during the collaboration were mostly between CF and DR. From the Nottingham viewpoint, DR mentioned, the NOT team members may need to adjust their 'working ethics'. When they usually work in the university, 'the way of working, less formal and people have freedom to come and go ... and obviously when they go to work in the company, they have to conform to company norms.' Regarding their working process as engineers and scientists, as DR pinpointed, the NOT team members do not need to adjust themselves to the RDD team because they have been trained to work in the same way as the engineers and scientists in the industry work.

On the individual level, the interface between CF and DR, from DR's point of view, DR did not need to adjust himself to CF because DR had several years of experience working in industry. And vice versa, CF also had experience of working with other universities. Therefore there is no need to adjust or adapt in any matter between CF and DR because of their previous experience on the collaboration. In short, on both teams and individual levels, both parties' teams

do not need to adjust themselves to each other, especially due to their working backgrounds and systems as scientists and engineers.

4.4.7 TOP MANAGEMENT SUPPORT

The level of Top Management support from both parties is different and unequal. Within BAE, Top Management has supported the collaborative projects in many different aspects. The essential commitment is the financial support. As CF mentioned 'the money is ultimately the best recommendation.' BAE has funded the whole collaborative project. Also, from the management viewpoint, as GO further mentioned, the company has also supported legal, technical and political aspects for the collaborative project. In the legal aspect, the company has set up all of the legal documents. In the technical aspect, the company allows the CF team setting up tasks and requirements. However, these are reviewed from Top Management. In the political aspect, the company gives 'trust' to the front-line research team who interfaces with the partner. GO stated, you can actually give them trust, to believe in their judgement, especially what needs to be done for developing new products.

Within Nottingham, DR mentioned that there is general background support from the University, such as laboratorial space and computer facilities. There is no special commitment for the NOT team. The University does not give any special attention or support to this collaborative project, such as extra money or resources. However, DR remarked the University has a policy to encourage the people go out and find funding from outside sources, such as Governmental sources or industries.

4.4.8 INNOVATION CULTURE

Both parties mentioned that the key issue of innovation culture within their teams depends on the quality of individuals within the team. From CF's point of view,

individuals joining the team have an essential contribution to the strong culture of innovation. CF mentioned four main characters that individuals should have within the team: 'it is important to have determination and driven commitment to couple with all inventiveness and intelligence.' Individuals should have creativity and be prepared to question things. They have to be intelligent. Also, they need to have a lot of driven commitment and determination not to give up easily when a problem arises or an unexpected failure exists.

From DR's point of view, individuals within the team must be innovative, without it really being defined. Also, they need to have the aspect of introducing changes and new ideas, and have the aspect of experiments along the developmental process. They need to find out which ideas would be the best for particular problems and examine those ideas. As DR mentioned, '...the whole process of development is all innovation.' Significantly, therefore, if individuals do not have this inquisitive nature, then innovative individuals would not exist. In short, both parties agree that the innovative qualities of individuals within the team contribute to the strong culture of innovation. The key innovative qualities of individuals are creativity coupled with the nature of driven-committed and determinate experiments.

Not only do individuals within the team need to have innovative qualities, but also innovation needs the right environment. From CF's point of view, he created an environment which is supportive and encourages people to be open. CF thought that 'you have to promote an environment where people prepare to speak, not be embarrassed or worry about being put down.' CF emphasised that 'if you knock people down when they come up with the ideas, then they will not offer anything.' Eventually, this environment gives opportunities for team members to show their abilities. In CF's opinion, this environment encourages team members to openly express their creativity and abilities, but does not increase their

creative abilities or help them to be more creative. From DR's point of view, DR motivated his team members to realise the benefits of the collaborative project and to understand the useful development resulted by their research. Also, DR built up a friendly, informal working environment for the team members; the NOT team members could contact him in any possible way if they had problems. Moreover, DR arranged a routine meeting with them, once a week.

4.4.9 PROBLEMS/CONFLICTS DURING THE COLLABORATIVE NETWORK

Considered from both partners' points of view, they agree and firmly point out that there were no conflicts and problems at all during the collaborative network. The collaboration worked very well. DR and CF expressed similar reasons. DR mentioned that 'not so far, I think that is because we started it off with something quite small and built up ... very happy with the arrangement ... and we seem to get on quite well on a personal level [with CF] as well, as there haven't been any conflicts so far.' And CF mentioned that 'certainly, not between myself and [DR]. So we've been very amicable and had lots of mutual respect...'.

As quoted above, DR thought the experience of a small project before the collaborative network started had built up a structural coupling of working relationship between both parties. The collaborative benefit satisfaction and interpersonal relationship are also the important issues. From CF's point of view, an amicable personality of both representatives and mutual respect are the significant factors. Also, both sides indicated the issue of mutual benefits. As CF mentioned 'they have to be obviously tremendous mutual benefit.' From DR's point of view, it is mentioned that 'disadvantages are none'. In conclusion, the mutuality between both parties is significant to decrease problems and conflicts during the collaboration.

4.4.10<u>CONCLUSIONS</u>

Focusing on the research information in Part 1, some significant factors during the successful collaborative network are revealed as the following:

(1) The legal agreement of the collaborative network. Three significant conditions are suggested: (i) intellectual property rights, (ii) payments and (iii) working conditions. This factor should be agreed before any collaborative project will be started. The evidence suggests that this factor supports the collaborative team for working openly, informally and effectively.

(2) The working concepts should comprise two main aspects: (i) informality and (ii) colleagues and equals. First, informality helps the collaborative team struggle less with a lot of processes or any formal management which may discourage the collaboration. Secondly, the aspect of colleagues and equals facilitates the motivation of the partner team. Also, the collaborative team can assimilate and learn more from the collaboration.

(3) Well-established working relationship. An amicable personality and mutual respect build up good working relationship. This factor helps decrease problems and conflicts during collaboration.

(4) Informal, flexible and short-term planned collaborative product development process. The flexibility sustains a long-term project. The short-term planning is suitable for innovation because, along this process, there might be unexpected circumstances which come up according to the nature of research projects.

(5) Effective communication. Both parties are satisfied with the arrangement of the methods of communication both informally and formally. This

arrangement works very well, especially formal route of communication which is based on flexible arrangement concerning the need basis. The flexibility is suitable for both parties' times. On the one hand, the NOT team does not need to regularly provide reports which are time-consuming. On the other hand, the RDD team, especially CF has limited time constraints because of his routine works. Not only is the arrangement very important, but the mutual understanding about the requirement of the collaboration is also. Any misunderstanding can cause difficulties of working relationship.

(6) Open information sharing. The evidence suggests that it would make the collaboration very difficult, if the collaborative team does not exchange any information openly. Similarly sharing, the motive of open information exchange from both parties is strengthened by trust. From the BAE viewpoint, trust on the personal level strengthens open information exchange. From the DR viewpoint, trust on the contractual level underpins it.

(7) Top Management commitment and support. In this case, Top Management strong support and high commitment in BAE is essential because BAE initiates the collaborative project. The key support is financial commitment that sustains the collaborative project. Though, there is no special commitment to the NOT team from Nottingham, on the other hand, the University has an apparent policy encouraging staff to link with external organisations.

(8) Innovative abilities of the collaborative team. Both parties agreed that the innovative qualities of individuals within both internal teams contribute to the strong innovation culture. Not only do individuals need to have innovative abilities, but they also need to be coupled with the nature of driven-committed and determinate experiments.

(9) The team environment. Both parties agreed that the right team environment cultivates innovative abilities. An open-minded, friendly and informal working environment is suggested. This environment will encourage the team members to openly express their creative ideas, abilities and/or problems.

(10) Good interpersonal relationship. Both parties have a similar attitude towards collaboration: the development of good relationship on the personal level, as reflected by their beliefs and behaviours. Both agreed that interpersonal relationships strengthen the relationship between the teams across organisations. In particular, the friendship of good interpersonal relationship promotes a long-term organisational relationship and is the basis of the collaboration.

4.4.11 REFECTIONS

Focusing on the point of research information, please note, during the interview, both parties revealed some sensitive issues which I cannot publish in this thesis. From my research ethics standing point, I believe that these issues may affect the good relationship between the organisations. Mainly, they were the expectations of both parties to improve certain matters. Both parties agreed and expressed their understandings by stating 'it would be better if something was improved.' From the study viewpoint, because of their mutual understanding, they accepted the imperfect conditions and tried to do their best to make the collaboration a success.

Turning to the point of other interesting issues which are not included in the main research questions, the study poses another two questions which should be analysed regarding this continuing collaborative network:

(1) Why had this collaborative network between BAE and Nottingham explicitly emerged and grown?

(2) Regarding question 1, what are critical bridges between both organisations?

4.4.11.1 THE EMERGENCE AND GROWTH OF THE COLLABORATIVE NETWORK

The emergence and growth of the continuing collaborative network between both organisations are analysed by the following conditions:

(1) There are a series of the continuing collaborative projects.

(2) There are jointly-arranged activities. For instance, within BAE, the NOT team members have annual industrial secondment for a couple of weeks with the RDD team. Also, one graduated PhD student was employed as the result of a collaborative project. Within Nottingham, the RDD team members are invited to join the annual presentation of the students' working progress.

To answer the first question, the collaborative network has emerged and grown on the following reasons:

MUTUAL COMPLEMENTARY INTEREST

The first reason is both parties have mutually complementary interest. DR indicated it as 'having mutual interest without being competing', though, GO mentioned, both parties have different interests.

For BAE, the company is interested in being healthy and a good supplier. It demands highly external specialised expertise to develop new conceptual products and to improve the performance of existing products. Such innovation will help the company maintain its good and rigorous position as the leading supplier in the market. The capabilities of the NOT team perfectly fit with the BAE interests.

For Nottingham, the NOT team is interested in developing capabilities and skills in technical analysis of mechanical engineering which is across a large number of potentially new product designs. From DR's point of view, DR wants the NOT team members (postgraduate students) to experience working on 'real world problems' and 'current state-of-the-art' to sharpen their research focus. Also, DR wants to access funding, facilities and professional expertise to enhance students' research capability. Moreover, DR wants the students to have working experience within the real industry to enhance their research training. According to these requirements, BAE has been willing to supply them in order to exchange with the expertise of the NOT team. In conclusion, mutual complementary, but not competing interest, motives the emergence and growth of the collaborative network.

MUTUAL BENEFITS

Secondly, the close correlation to mutually complementary interest is mutual benefits. Both parties must have mutual benefits out of the collaborative network. My study believes that mutual benefits are directly related with mutual interest. To reach the optimum point of each party's interest, the party reckons its own benefits to justify collaboration. Each party's interest and benefits will be brought to negotiate simultaneously. As a result, mutually complementary interest not only has to optimise both different parties' interests, but also has to satisfy both parties' benefits. In this case, both parties negotiated the benefits of collaboration so that each would be earned to fulfill its own interest.

According to BAE's main interest, the company is very concerned with the intellectual property rights (IPR). GO mentioned that it is important for the company to keep controlling every patent surrounding gyro-based products because these intellectual properties are critical for the company's business, the SG. As a result, the collaboration would not exist, if the negotiation of IPR is

dissatisfied. GO pointed that some Universities think that they must keep IPR. Under this circumstance, this leads the Company to simply end up not doing a business with some of them. In any case, BAE will not collaborate with any other external specialised organisation, if the benefits have not been satisfied by the company's main interest. The RDD team summarises the benefits of the collaborative network: First, it enhances in-house Company skills and knowledge because technical thoughts are provided during the collaboration. Secondly, after finishing each collaborative project, a copy of the research document is granted. Thirdly, BAE can hire good students that the Company has time to know them during the collaboration. As CF commented,

"You get a much better view of their capability than you have of people who came in, possibly in the interview. No matter how long the interview is.... You can get a different view, only very limited on somebody characters and capabilities."

CF suggested that not only does BAE get the mere benefits from this collaborative network, but the NOT team also gains them in several ways too. For instance, it helps students to have more focus on their works. The students have a chance to work on real applications rather than just to work on abstract or theoretical applications. Also, it provides the research activities which it could not get from the course in the University. Also, the NOT team gets funding and scholarship for generating interesting research.

On the other side, according to the main interest of the NOT team, the team is concerned very much with the opportunities to work on existing product problems, to work with industry, to access research funds, and to publish new research findings. Therefore, the negotiation of the benefits from the NOT team is based on its mentioned interests. As expected by the NOT team, BAE would be able to offer these benefits.

To sum up the second reason: the factor of mutual benefits which both parties' interests is likely to be maximised is significant for the emergence of this collaborative network. This factor needs to be agreed by both parties. It definitely helps to strengthen and grow the collaborative network.

MUTUAL TRUST

The third reason is the factor of trust. In this case, trust has been built up by the complex combination of many circumstances, such as personal relationship, legal contract and both parties' capabilities and reputation. As the result, the growth and emergence of this collaborative network are based on mutual trust. From the analysis, there are two levels of mutual trust existing in this collaborative network: (1) mutual trust at the organisational level and (2) mutual trust at the personal level. More likely, both levels link and influence each other. My study theorises two possibilities: (1) the increase of mutual trust at the organisational level is likely to increase mutual trust at the personal level and (2) the decrease of mutual trust at the personal level is likely to decrease mutual trust at the organisational level. First, the mutual trust at the organisational level has directly correlated with mutual benefits and interests. In this case, it is well established because both parties are agreed on their own benefits and simultaneously their interests are mutually maximised. Moreover, both parties strengthen their mutual trust at this level by signing the legal contractual agreement. This legal agreement consists of the basic rules during the collaboration, such as IPR, payment, working conditions and Non Disclosure Agreement. This agreement has been done on the organisational level.

Secondly, the mutual trust at the personal level is directly related to working experience between both parties. The mutual trust has been developed from the experience of working together between the main points of contact who have

responsibilities to work as the front-line interface. From CF's point of view, trust has been developed and strengthened by good personality of the partner representative, good personal relationships, and the quality of the partner's works. From DR's perspective, good personal relationships, common interests and clear agreements on IPR, confidentiality and publications have strengthened trust. Moreover, this mutual trust has been cumulated when they experienced working together on the first sub-contract project. Furthermore, there are other personal issues which strengthen this mutual trust, including mutual respect and understanding.

In short, the mutual trust is the complex issue. This case study suggests that the mutual trust in the personal level has correlated with the mutual trust in the organisational level. The mutual trust in the personal level has been strengthened by the mutual trust in the organisational level and vice versa. The growth of collaboration tends to be the result from the mutual trust in the both levels.

CONCLUSION

In conclusion of the first question of why the collaborative network between both parties has explicitly emerged and grown, three key factors are identified. The first factor is mutual complementary interest. Both parties in the collaborative network have their own ultimate expectations which need to be mutually satisfied. This factor helps motivating the collaborative network. The second factor is mutual benefits that maximise both parties' interests. The third factor is mutual trust in both organisational and personal level. Both factors help strengthening the collaborative network.

4.4.11.2 THE CRITICAL BRIDGE

To answer the question 2, the critical bridges of the collaborative network are the knowledge link and the complementary exchange link. Through the collaborative

network, from the beginning to current year (2003), firstly, the knowledge link is essential. At the beginning, the first project was initiated by BAE. BAE needed a specific knowledge, which the company doesn't have in-house, which is very significant to develop the performance of new products. Nottingham was selected because of the reputation of DR. DR can provide such knowledge which satisfied the specific need. The knowledge link is getting stronger in this collaborative network because the NOT team can not only provide solutions of new product problems, but also introduce new knowledge to create new product concept in the future.

Secondly, the complementary exchange link strengthens the knowledge link and helps the emergence and growth of collaborative projects. This link is defined as the mutual exchange between organisations which demand and supply are different. Though the goods to be exchanged are different in physical properties and values, they are assessed equally and fairly during the process of exchange. In this case, on the one hand, the NOT team mainly needs supports, such as finance, facilities and professional expertise and the development of research students' capabilities and skills. On the other hand, BAE needs merely specific knowledge which will be used in the development of new products in the future. The demand of the NOT team is supplied by BAE and vice versa.

To sum up, the critical links for strengthening this collaboration are the knowledge link and the complementary exchange link which can provide the satisfied benefits for the collaborative team. Conclusively, the most critical link would be the knowledge link because if BAE does not need the specific knowledge from the DR's team, there would be more likely that this collaborative network may be disconnected. As CF mentioned '...maybe in five years time that we have a very mature product and we don't need to do a research on it...we are not working with Nottingham because there is no longer any requirement.'

4.5 ANALYSIS 2: IDENTIFYING CRITICAL FACTORS

The following sections are resulted from the analysis of the research questions in Part 2 of Interview Script 1. The critical factors are divided into three main categories as the following:

4.5.1 WITHIN THE COLLABORATION

From the analysis of all answers (please see Table 4-1 in Appendix 4) from the direct, open-ended question, *'what were underlying critical factors in the collaborative team across organisations which underpinned the success of new product collaboration? And why?'* nine critical factors are identified. Two are agreed by both organisations:

(1) Mutual interest needed to be complementary.

(2) Clear, well-defined legal side of intellectual property, especially at the beginning of the collaborative project

Seven other critical factors are individually mentioned:

(1) Good working relationship (NOT's viewpoint)

(2) Mutual trust, being confident of each other (BAE's viewpoint)

(3) Mutual benefits (BAE's viewpoint)

(4) Good personal and working communication in both personal level and technical level (BAE's viewpoint)

(5) Mutual understanding of the collaborative parties' skills and distinctive characteristics (BAE's viewpoint)

(6) Clear definition of the collaborative project requirement or understanding the clear objective/requirement of the collaboration (BAE's viewpoint)

(7) The right partner should have not only a right capability, but also a right mindset (BAE's viewpoint)

4.5.2 WITHIN THE TEAM/ORGANISATION

From the analysis of all answers (please see Table 4-2 in Appendix 4) from the direct, open-ended question, *'what were the underlying critical factors in your team and organisation which underpinned the success of new product collaboration? And why?'* seven critical factors are identified. One is agreed by both organisations:

(1) Having 'good, strong research' people in the team. DR identified 'good' as "clever and well self-motivated, work hard and commitment".

Six other factors are individually mentioned:

(1) Good support from team leader, such as facilities and supervision (NOT's viewpoint)

(2) Good environment for networking within the team (NOT's viewpoint)

(3) Building up external network which is related to the team's works (NOT's viewpoint)

(4) Ability to communicate well and openly (BAE's viewpoint)

(5) Good organisational structure (BAE's viewpoint)

(6) Top management support both political support and financial commitment (BAE's viewpoint). For political support, GO mentioned that trust have to give to the front-line research.

4.5.3 BETWEEN THE MAIN POINTS OF CONTACT

From the analysis of the answer (please see Table 4-3 in Appendix 4) from the direct, open-ended question, *'Regarding your role as a main point of contact between your partner and organisation, what was your critical contribution that made the collaboration a success?'* CF identified three critical factors which contributed to the success of collaboration with the partner:

(1) Developing a good personal relationship.

(2) Understanding the external partner's knowledge and role

(3) Establishing the effective methods of communication for the collaborative team

Also, CF identified two critical factors of the role within BAE which supported the collaboration success:

(1) Promoting and strongly supporting the benefits of this collaboration to top management

(2) Applying the by-product of the collaborative research to develop the better in-house products

Please note, this question was developed after I finished interviewing DR and GO. Regarding the network case study methodology, please see details in Section 3.7.2.1, CF is a cut point, which is the most critical actor within the collaborative network. As a result, CF was the mere research participant in Case Study 1 answering this question.

4.6 ANALYSIS 3: THE ASSESSMENT OF KEY FACTORS

The following sections resulted from the analysis of the research questions in Part 3, *'Please identify how critical the following indicators were which underpinned the success of new product collaboration and give me your reasons to support any answer.'* Please see the research outcome in Table 4-4 and the analysis of the value and the level of mutuality of each key factor in Table 4-5 in Appendix 4. Please note, my study adopts the concept of the bridge to interpret critical factors (please see details in Section 3.8.3). As a result, the assessments of the key factors in my hypothesis and the level of mutuality of each key factor from DR and CF are mainly used for the analysis. GO's assessment is used as supportive information.

Regarding twelve factors in my hypothesis, eight factors are valued as of 'critical':

(1) Trust in the abilities of the partners. Trust is really critical element for working relationship, especially for joint effort. It helps to save a lot of time and costs during collaboration. Especially, if the organisation performs as the collaboration initiator, trust has to put in the first place. CF mentioned 'the company needs to make sure that the partner is right and good value for money.'

(2) Effective communication, especially between the main points of contact during the collaboration. This helps to save time and to work more effectively and efficiently. It also enables open communication and encourages open discussions on difficult issues. Moreover, it helps to avoid frustration.

(3) Commitment of the collaborative team. It helps the collaborative team work as a single team. Also, it sustains collaboration and drives the project success. Moreover, it helps to build up a long-term relationship.

(4) Joint problem-solving concerning new products. From the BAE management viewpoint (GO), the main objective of this collaboration is to solve problems together. It helps motivation. It also helps to save time in solving problems and work more effectively.

(5) Top Management support. It increases encouragement to work, network and/or collaborate with external organisations. Also, it helps motivate and give confidence to in-house team in the collaborative project.

(6) Close interpersonal relationship, especially between the main points of contact. It helps in sharing and exchanging ideas and information openly, and also to build up mutual trust and respect.

(7) Open information exchange. Significantly, core information related to collaboration, such as technical knowledge and ideas needs to be openly exchanged and easily to be accessed. It helps to be able to communicate effectively. Also, it protects failures of delivering solutions and supports. Moreover, it sustains the joint activities. Furthermore, it helps to build up mutual trust.

(8) Innovation culture of the organisation. It provides encouragement and support.

The following factors are valued as of 'little important' to 'unimportant' for the collaboration's success and have low level of mutuality between the collaborative organisations:

(1) A well-planned product innovation process. Most of the collaborative projects are involved with technical analyses which are a minor part of the whole product innovation process. This collaboration is a joint design process contributing to product innovation. From the BAE management viewpoint, GO mentioned that 'innovation cannot be planned'.

(2) In-house team adaptability. Neither of the partners' team worked together that much during the collaborative process. Also, the main points of contact have extensive experience on working with external

organisations before. So, adaptability is of little importance for this collaboration.

(3) Joint decision-making concerning new products. In this collaboration, this depends on BAE. Most of the decision-making process concerning new products will be the responsibility of BAE because the company needs to outlay a lot of cost in producing new products. So, this key factor is of unimportant for this collaboration.

One key factor, 'innovative abilities of each in-house team' (i.e. the innovative abilities of the members of each in-house team who participate in the collaborating project), is not mutually agreed as to its value. This is because the involvement of both in-house teams is not equal. Most of the NOT team members worked for this collaborative project. However, the RDD team members did not get involved in it. From the NOT viewpoint, it is suggested that this factor helps to solve the routine problems, and also make a positive contribution to the joint effort. From the BAE viewpoint, this factor is extremely critical to the Company, as GO mentioned, 'without that we haven't got the product'.

4.7 SUMMARY OF CRITICAL FACTORS

Please note: the results of the analyses in Section 4.4 – 4.6 are cross-analysed. Please see the collective outcomes of all key factors from three Sections in Table 4-6 in Appendix 4. Critical factors are summarised by categorising key factors of all three sections into different, relevant units (see the details of the research analysis method in Section 3.8.2). The critical factors underlying this successful collaborative network in the development of innovative products and their reasons are:

1. TRUST

Trust is related to working relationships. The successful collaboration is an activity based on trust. The collaborative team needs to be confident and believes in the abilities of each other. Also, Top management of each organisation needs to trust its in-house team's judgement and information provided.

2. COMMUNICATION

Communication maintains working relationships. Three matters are mainly concerned: (a) effective methods of communication, (b) ability to communicate well, and (c) open information exchange.

3. RELATIONSHIP

Relationship strengthens communication and trust. Two types of relationship need to be maintained. First, close interpersonal relationship is very helpful. The personal relationship should be developed. Secondly, a good working relationship is significant.

4. TOP MANAGEMENT COMMITMENT AND SUPPORT

In this case study, high commitment and continuous support, such as financial resources and political support helps to motivate and give confidence to in-house team in the collaboration.

5. CULTURE OF INNOVATION

The culture of innovation should be promoted within the team and organisation. The following matters are concerned: (a) good support from the team leader, (b) good organisational structure, (c) good working environment within the team and (d) the encouragement of external contact.

6. A CLEAR DEFINED OBJECTIVE OF COLLABORATIVE PROJECT

The collaborative team must have clear definition of the collaborative project requirement before the project starts. The clear objective helps the team across organisation to work as a single team and avoid disappointments and misunderstandings which may destroy relationships.

7. MUTUAL BENEFITS

The benefits of the collaborative organisations must be clear and well-defined by the collaborating organisations before the collaboration officially starts, especially IPR.

8. MUTUAL INTEREST

The collaborative project must be set up and based on the interest of both parties in which their skill and knowledge need to be complimentary to each other.

9. IN-HOUSE TEAM ABILITIES

Each in-house team should have people who have the following abilities; inventiveness, hard work, self-motivation and commitment to the project.

10. JOINT PROBLEM-SOLVING

The good collaborative team across organisations should openly share their knowledge, information and ideas to solve design problems related to new product together. This helps to solve problems much quicker and works much more effectively.

11. ENSURING THE RIGHT PARTNERS

The right partner needs to have not only the right capability, but also the right mindset to be helpful. This avoids mutually disappointed during collaboration.

In conclusion, ten out of eleven critical factors are agreed by both organisations. One factor, 'Ensuring the right partners' is not mutually agreed. The ten factors are likely to contain high level of mutuality between the collaborating organisations. The findings suggest that within these critical factors, attitude, behavioural and communication aspects among the collaborative participants and organisations emerge to be the key issue. These aspects will be further observed in Case Study 2.

APPENDIX 4

Table 4-1 reveals all answers of three research participants who mentioned underlying critical factors within the collaborative team which underpinned the successful collaborative network in the development of innovative products

INTERVIEWEES	CRITICAL FACTORS	REASONS
DR (NOT)	1. Mutual interest which is needed to be complementary	Na
	2. Good working relationship	Na
	3. Well-defined legal side, especially intellectual property	Na
	4. Confidence in each other that the collaboration is worthwhile	Na
CF (BAE)	1. The benefits of both parties (Mutual benefits)	Na
	2. Complementary skills, that the partners need, which are based on mutual interest	If we have in-house skill, we would not get to external expertise because we have no need to do so.
	3. Good personal and working communication, not only on personal level but also on every technical level (speaking the same language)	Na
	4. Mutual understanding of the intrinsic nature of work, and skills between partners	Na
GO (BAE)	1. Clear definition of its requirement	It avoids the disappointment and misunderstanding which destroy most relationship
	2. Ensuring the partner that you got is right. "Right person does not only academic capable of working out the answer, but also they have to be right mindset to be helpful."	It avoids mutual disappointed between collaborative parties
	3. Clear mutual benefits of intellectual property, especially officially to collaborative parties at the beginning of the project	It has to be win-win situation
	* It helps if you feel like a person. He is really nice. He does not cause any problems. And he keeps his promise.	Na

Table 4-2 reveals all answers of three research participants who mentioned underlying critical factors within the team and organisation which underpinned the successful collaborative network in the development of innovative products

INTERVIEWEES	CRITICAL FACTORS	REASONS
DR (NOT)	1. Good people in the team, such as clever and well self-motivated, work hard and commitment	Na
	2. Well support in terms of facilities and supervision from the team leader	Na
	3. Good environment for networking within the team	Na
	4. Building up external contact which is related to their work	Na
CF (BAE)	1. Ability to communicate well and openly	This helps to share necessary information, to be able to communicate and be able to continue working relation and build up relationship. It would have all gone wrong, if the team lacks of it.
GO (BAE)	1. Good organisational structure	To reduce a long managerial procedure, so the team can concentrate on their research and development
	2. Having good, strong research in the research department	Na
	3. Trusting them about their information	Na
	4. Making sure that funding is continuing for the project	Na

Table 4-3 reveals the answer of one research participant who mentioned underlying critical factors as the main point of contact which underpinned the successful collaborative network in the development of innovative products

INTERVIEWEES	**CRITICAL FACTORS**	**REASONS**
CF (BAE)	1. CF guesses that 'developing good personal relationship	Na
	2. The ability to understand partners' knowledge and what they are doing on the collaborative project	Na
	3. To establish a way of communicating enough of knowledge in both directions	To work efficiently
CF (BAE)	1. To promote and strongly support the developing of this partnership with external expertise (DR)	Na
	2. To use that research information for developing the highly successful project	Na
	Remarks: CF mentioned that "that difficult question of what make you successful I don't know"	Na

Table 4-4 reveals the assessment of key factors in my hypothesis which underpinned the successful collaborative network in the development of innovative products

KEY FACTORS	INTERVIEWEES			REASONS
	DR	CF	GO	
1. Close interpersonal relationship between you and your partners' representatives	4	4	3	DR: You can have successful project without really close, good such as personal relationship. It is really helpful. CF: It makes communication very much easier. It helps in sharing ideas openly and building up mutual trust and respect. GO: Relationship was very strong part of the partnership. It has to be a good relationship between you.
1.1. Close relationship between the team across organisations	3	3	3	DR: Needing good relationship between the team to get access information and arrange necessary meeting for the project. CF: DR's team and CF's team do not need to contact directly very much. Mostly, DR and CF are the interface of the two teams. GO: As mentioned above
2. Trust in the abilities of the partners	5	5	4-5	DR: You can't really collaborative properly without trust. Trust is really critical for working relationship,... especially for "joint effort". The collaborative project will waste lots of costs and times if the collaborative team does not confidently trust each other when they collaborate. CF: It is a lot of money to spend. So, we must be completely sure that the partner is right and good value for money. GO: The organisation gives those front-line researchers who interface with the university to give them trust to believe their judgement and what they said.
3. Well-planned product innovation process during the collaboration	2	3	3	DR: The process does not directly affect this collaborative project. However, DR thinks that this process is very important within the BAE Systems. It supports the initiation of the collaborative project. CF: The collaborative project is not the critical part of product development because of the time scales of students' projects. The company does not rely on the collaborative project that much in order to deliver the business. GO: It has to be done... You can't plan innovation.

KEY FACTORS (Continued)	INTERVIEWEES			REASONS
	DR	CF	GO	
4. Joint problem-solving concerning new products	4	5	4	DR: It provides motivation. CF: CF must depend on DR's team in solving very difficult problems which CF's team does not have in-house expertise. CF's team cannot solve the problems without DR's team. Especially, theoretical solutions have to need to be tested and implemented. It helps to solve the problems much quicker and work much more effectively. GO: Because they are doing work to solve the problems.
5. Joint decision-making concerning new products	2 or 3	1	2	DR: This indicator is irrelevant for this collaborative project. The decision-making concerning new products depends on BAE Systems. DR does not get involved in that so much. CF: DR's team does not have an influence and/or a say on what CF's company products will be produced or made. GO: It is the company's money. So, the company has a right to make a decision.
6. Effective communication between the team across organisations	5	2	3	DR: (1) It saves time. (2) It avoids frustrations. (3) It enables everybody to work more effectively and efficiently. CF: The team across organisations does not involve in the communication. CF and DR handle the whole communication. GO: Effective communication is very strong part of the partnership.
6.1 Effective communication between you and your partners' representatives	5	5	2	DR: (1) It saves time. (2) It avoids frustrations. (3) It enables everybody to work more effectively and efficiently. CF: It helps to clarify what each partner wants out of the collaboration. It enables open communication. It affects the ability to do work. It encourages open discussions on difficult issues, such as funding or spending more money on DR's team. GO: Because, for me personally it is little important, that's down to CF.

KEY FACTORS (Continued)	INTERVIEWEES			REASONS
	DR	CF	GO	
7. Open information exchange	4	4	4	DR: Not all information that DR needs to know and BAE Systems would want to tell. He thinks it is very important to have access to information which DR's team really needs. However, peripheral information, such as commercial consideration would not be important for this project. CF: It helps to be able to communicate effectively. It protects failure of delivering solutions and supports for the joint activities. GO: Without that you don't trust each other.
8. Innovative abilities of your in-house team	4	3 or 2	5	DR: It enables DR's team not only to solve routine problems but also to make a positive contribution to the joint effort. CF: CF's team does not participate with DR's team. Mainly, CF has most of discussions with DR. CF's team members do not get involved. GO: Without that we haven't got the product.
9. Innovation culture of your organisation	4	4	3	DR: Nottingham University constantly encourages innovation. The innovative nature of engineers is innovation culture that encourages the collaboration success. CF: It is very significant for our technical business. It provides numerous encouragement and supports, especially spending a lot of money on adventurous technical project. GO: Without innovation, you don't remain competitive. It doesn't become very critical because the whole organisation doesn't affect the research team.
10. Top management commitment and support	4	4 or 5	5	DR: It gives encouragement to work, network or collaborate with outside industries. This helps decreasing the level of an intellectual snob attitude of academia, "we should not do these things with the industry". CF: It needs a big financial commitment. Therefore, top management commitment is very critical to continually support for the project. GO: Without that, the research team doesn't feel that they got support. They wouldn't really get long-term view what projects need to carry on. Also, you can't have a situation where various parts trust each other, unless they know the senior management will put the right thing.

KEY FACTORS (Continued)	INTERVIEWEES			REASONS
	DR	CF	GO	
11. Commitment of the team across organisations	5	5	5	DR: It sustains the collaboration and drives the project success. CF: It sustains collaboration. Also, it assists to build up long-term relationship. GO: They are in partnership working as a single team. Unless, you have a joint objective, you don't succeed as a team. Also, you don't have a team without different objectives and people.
12. Your in-house teams' adaptability (to your partners)	3	2	2	DR: Most of DR's team members spend their time in their own organisations. It is not necessary to be adaptable that much. CF: It is only a couple of weeks a year that students come to work in our team. So, it is not really important to the collaboration. GO: It is very important but it is not necessarily to the collaboration. Because external environment changes, such as the requirement changed, the discovered problems changed, the requirement of the market place changed. Therefore you can't continue solving the same problem.

Table 4-5 reveals the analysis of the value and the level of mutuality of each key factor

KEY FACTORS	INTERVIEWEES		VALUE OF EACH KEY FACTOR	LEVEL OF MUTUALITY
	DR	CF		
1. Close interpersonal relationship between you and your partners' representatives	4	4	Critical	High (4)
1.1. Close relationship between the team across organisations	3	3	Important	Medium (3)
2. Trust in the abilities of the partners	5	5	Critical	High (5)
3. Well-planned product innovation process (during the collaboration)	2	3	Little important	Low (2.5)
4. Joint problem-solving concerning new products	4	5	Critical	High (4.5)
5. Joint decision-making concerning new products	2-3	1	Unimportant	No (1.75)
6. Effective communication between the team across organisations	5	2	Important	Medium (3.5)
6.1 Effective communication between you and your partners' representatives	5	5	Critical	High (5)
7. Open information exchange	4	4	Critical	High (4)
8. Innovative abilities of your in-house team	4	3-2	Important	Medium (3.25)
9. Innovation culture of your organisation	4	4	Critical	High (4)
10. Top management commitment and support	4	4-5	Critical	High (4.25)
11. Commitment of the team across organisations	5	5	Critical	High (5)
12. Your in-house teams' adaptability (to your partners)	3	2	Little Important	Low (2.5)

Remarks: The value range of each key factor after the analysis: 4-5 = critical, 3-3.99 = important, 2- 2.99 = Little important, 1-1.99 = Unimportant
The level value of mutuality: 4-5 = High, 3-3.99 = Medium, 2-2.99 = Low, 1-1.99 = No Mutuality

Table 4-6 illustrates the collective research outcomes of key factors from the three parts

RESEARCH OUTCOMES OF PART 1	RESEARCH OUTCOMES OF PART 2	RESEARCH OUTCOMES OF PART 3
☐ Mutually complementary interest (MA)	☐ Mutual interest needed to be complementary (MA)	☐ Trust in the abilities of the partners (MA)
☐ Mutual benefits which the collaborative parties' interests must be likely maximised (MA)	☐ Clear, well-defined legal side of intellectual property, especially at the beginning of the collaborative project (MA)	☐ Effective communication, especially between the main points of contact during the collaboration (MA)
☐ Mutual trust in both personal and organisational levels	☐ Good working relationship (IM, DR)	☐ Commitment of the collaborative team across organisations (MA)
☐ The knowledge link with sharing a common interest	☐ Mutual trust, being confident on each other (IM, CF)	☐ Joint problem-solving concerning new products (MA)
☐ The complementary exchange link	☐ Mutual benefits (IM, CF & GO)	☐ Close interpersonal relationship, especially the main points of contact during the collaboration (MA)
☐ The legal agreement of three fundamental conditions, intellectual property right, the payments and the working condition (MA)	☐ Good personal and working communication in both personal level and technical level (IM, CF)	☐ Open information exchange (MA)
☐ The working notions should consist of two main ingredients: (1) informality, and (2) colleagues and equals (IM, CF)	☐ Mutual understanding of the collaborative parties' skills and distinctive characteristics (IM, CF)	☐ Innovation culture of the organisation (MA)
☐ Working relationship which has to be well established during the collaboration. Regarding this collaboration, an amicable personality and mutual respect have built up working relationship (IM, CF)	☐ Clear definition of the collaborative project requirement or understanding the clear objective/requirement of the collaboration (IM, GO)	☐ Top management support (MA)
☐ Informal, flexible and short-term planned collaborative design process across organisations (IM, CF)	☐ The right partner should have not only a right capability but also a right mindset (IM, GO)	
☐ Joint problem-solving process concerning new design (MA)	☐ Having 'good, strong research' people in the team. DR identified 'good' as "clever and well self-motivated, work hard and commitment. (MA)	
☐ Mutually satisfied and convenient on the methods of communication both informally and formally (MA)	☐ Well support from team leader, such as facilities and supervision (IM, DR)	
☐ Mutual understanding about the requirement of the collaboration (IM, GO)	☐ Good environment for networking within the team (IM, DR)	

RESEARCH OUTCOMES OF PART 1 (Continued)	RESEARCH OUTCOMES OF PART 2 (Continued)	RESEARCH OUTCOMES OF PART 3 (Continued)
☐ Openly share information (MA)	☐ Building up external network which is related to the team's works (IM, DR)	
☐ Top management support: Financial support (CF), Political aspect, trust (GO) and Policy (DR)	☐ Ability to communicate well and openly between the main points of contact (IM, CF)	
☐ The innovative qualities of individuals within the team contribute to the strong culture of innovation (MA)	☐ Good organisational structure (IM, GO)	
☐ The team environment. Open-minded, friendly and informal working environment is suggested (IM, CF)	☐ Top management support both political support and financial commitment (IM, GO)	
☐ Good interpersonal relationship towards friendship between the main points of contact (MA)	☐ Developing good personal relationship (IM, CF)	
	☐ Being able to understand the external partner's knowledge and role (IM, CF)	
	☐ Establishing the effective methods of communication for the collaborative team across organisations (IM, CF)	
	☐ Promoting and strongly supporting the benefits of this collaboration to top management (IM, CF)	
	☐ Applying the by-product of the collaborative research to develop the better in-house products (IM, CF)	

Remarks: MA means 'Agreed'; IM means 'Individually Mentioned'. DR represents the NOT team. CF and GO represent the RDD team.

CHAPTER 5: CASE STUDY 2

THE COLLABORATIVE NETWORK BETWEEN REMOTE CONTROLLED LIGHTING LTD AND CAMBRIDGE DESIGN PARTNERSHIP IN THE DEVELOPMENT OF THE REMOTE CONTROLLED LIGHT

INTRODUCTION TO CHAPTER 5

Chapter 4 discusses the collaborative network between Nottingham and BAE in the development of a Silicon Gyroscope. Chapter 4 identifies eleven underlying critical factors contributing to the success of the collaborative network. Case Study 1 suggests that these critical factors tend to contain high level of mutuality between the collaborative organisations.

Chapter 5 describes the investigation of Case Study 2: a successful collaborative network between Remote Controlled Lighting Ltd (RCL) and Cambridge Design Partnership (CDP) in the development of their Remote Controlled Light (RL). The sections are as follows:

Section 5.1 describes general details of Case Study 2.

Section 5.2 details the research approach of Case Study 2.

Section 5.3 describes the background information of Case Study 2, including the product specification of the RL, background of the collaborative organisations, background of the collaborative team, and background of the collaborative network.

Section 5.4 describes the analysis of the research questions in Part 1 of the Interview Script 1, focusing on the detailed story of Case Study 2. The main topics of the analysis are: the arrangement of the collaborative network, a collaborative product development process, communication, information exchange, relationship, adaptability, Top Management support, innovation culture, problems/conflicts during the collaborative network, and suggestions to improve the collaborative network. Section 5.4 also summarises the research findings derived from the research questions in Part 1.

Section 5.5 describes the analysis of the open-ended research questions in Part 2 of Interview Script 1, focusing on the identification of critical factors. The analysis of critical factors is divided into three main categories: critical factors within the collaborative network, critical factors within each team/organisation, and critical factors between the main points of contact.

Section 5.6 describes the analysis of the close-ended research questions in Part 3 of Interview Script 1, focusing on the assessment of how critical key factors in my hypothesis are and the level of mutuality of each key factor.

Section 5.7 summarises critical factors derived from the research findings of Case Study 2.

Section 5.8 asserts reflections and comments of the research findings of Case Study 2.

5.1 INTRODUCTION

The RL is the outcome of the successful collaborative network between RCL and CDP. This case study was found by the second pilot study. Please see the details of the second pilot study in Section 3.1.2. Initially, RCL outsourced CDP to design the RL. Because of the uncertain nature of innovative product development, however, RCL and CDP agreed that working collaboratively was more productive.

5.2 RESEARCH APPROACH

Three persons from both organisations contributed to this network case study information. The following three research participants are:

- ☐ Joe Ruston (JR), RCL Managing Director. JR worked as the internal project manager and the main point of contact during the collaboration.
- ☐ Mike Beadman (MB), CDP Managing Director. MB worked as the internal project manager of the collaborative project.
- ☐ X, a participant in the CDP design and development team.

Before the research could start, I contacted MB to ask for permission to investigate this project. As a matter of authority, MB was willing to participate in this research. However, the authoritative permission had to come from JR. MB gave me JR's contact details. After officially contacting JR, he was willing for me to investigate this project.

Two research methods are used: a structured, face-to-face interview and a questionnaire. At the beginning of this case study research, JR and MB were interviewed. Please see Interview Script 1 in Appendix C-3. As a result of the analysis of Case Study 1, Interview question 1 was adjusted. There were other minor improvements, including question wordings and adding more questions. In Part 2, the following question is added: 'Regarding your role as the main point of

contact during the collaboration, in your opinion, what was your critical contribution that supported the collaborative project success?' In Part 3 the following key factors had been added in my hypothesis: (i) clear, well-defined collaborative objectives and (ii) the working system adaptability of your in-house team. X was contacted after the analysis of JR and MB to strengthen the research result. X participated in the research by answering the questionnaire. Please see the Questionnaire 4 in Appendix C-4.

5.3 BACKGROUND OF CASE STUDY

5.3.1 BACKGROUND OF THE REMOTE CONTROLLED LIGHT (RL)

Picture 5-1 illustrates two components of Remote Controlled Light, Spot Light Case (left) and Infrared Remote Control (Right)

The RL was initiated by JR at RCL. It is a type of spot light which can be controlled by utilising infrared remote control. Its innovative concept is the use of existing infrared technology to solve the existing problem of adjusting display lights in high ceiling space. The design is intended to have 'neutral personality', simple shape, colour and form. JR mentioned, in the lighting market, if the light

has a strong personality, all other chains from hotels to retailers might not want to use it because it might be an identity of others.

This product was designed for use in public, commercial, or exhibition spaces that have very high ceilings, such as exhibition halls, restaurants and retail spaces. The product was released when I conducted my research.

5.3.2 BACKGROUND OF THE COLLABORATIVE ORGANISATIONS

Two organisations worked collaboratively in this network:

5.3.2.1 RCL was established by an entrepreneur, Joe Ruston (JR). It is a small, start-up marketing enterprise. It mainly retails remote controlled lights. There are no in-house production and design teams. The enterprise connects and interacts with other external organisations to design and manufacture its products.

5.3.2.2 CDP is a small-sized product development consultancy. It specialises in engineering and industrial design. The company has routinely worked in close contact with other external organisations by consulting in designing and engineering new technology for physical, manufacturing products.

5.3.3 BACKGROUND OF THE COLLABORATIVE TEAM

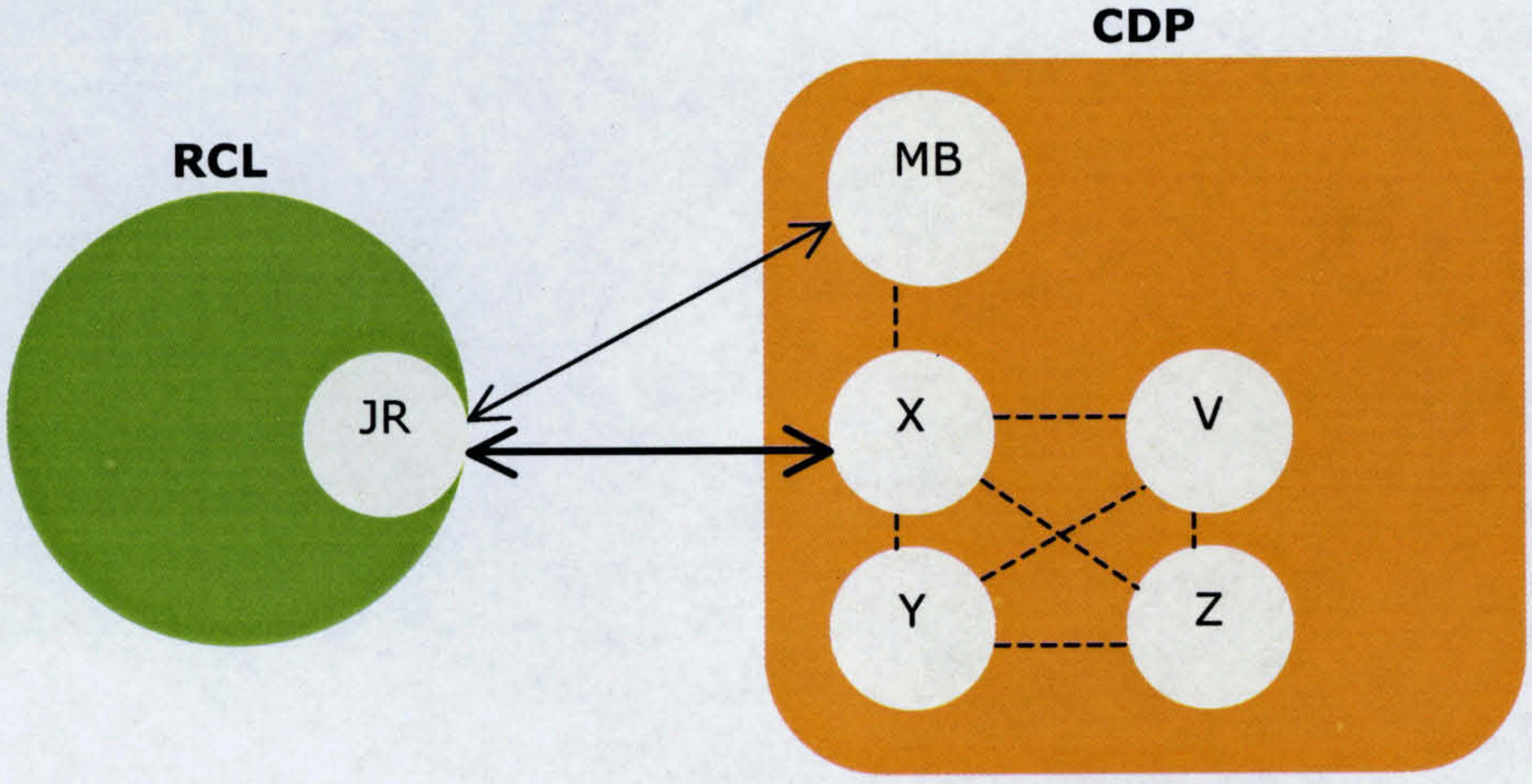
As shown in Diagram 5-1, the collaborative team was comprised of two main teams: a RCL team and a CDP team.

5.3.3.1 The RCL team is RCL's in-house team. It consisted of one person, JR. JR was the client and performed as the main point of contact. In this project, JR provided regular guidance and feedback. JR mentioned:

"I think it's true probably in general by every professional where there is an engineering consultant, solicitor, accountant, or all these guys are very good at their job. But they can't do their job unless you provide them with regular guidance and feedback."

5.3.3.2 The CDP team is CDP's in-house team. It consisted of five persons. MB was Project Manager. MB's roles were to manage the project from an overview, to keep the project on track, to keep clients informed when necessary and to internally review the project. X worked as a mechanical engineer. V, Y, Z and other in-house staff were slotted in when needed. Y and Z were electronic engineers. V was an industrial designer. The CPD team was responsible for engineering this product and designing its appearance.

Diagram 5-1 depicts a broad overview of the collaborative team



As shown in Diagram 5-1, JR worked closely with X. From time to time, JR and MB discussed the problems and the progress of the collaborative project.

5.3.4 BACKGROUND OF THE COLLABORATIVE NETWORK

At the initial stage, this project was started when JR worked as UK Managing Director of a Lighting Company A. After the first phase was done, Company A decided to drop the concept. However, JR decided to carry on this project and set up his own company, RCL. Because RCL had no in-house design team at that time, JR was looking for an engineering design consultancy which would not try to take part of the intellectual property. JR mentioned:

"I wanted a firm that would not try to take part of the intellectual property and... a lot of people from CDP came from a very big organisation, [Z]. [Z] has this policy of retaining the intellectual property and licensing it to their clients... Well, I certainly felt if I was gonna (sic) spend a lot of money, I wanted them to then have that money effectively invested in intellectual property with my consultant."

CDP was selected after JR had talked with several engineering design consultancies and also by the recommendation of a person who JR worked with on the first version of the RL. From the consultant's viewpoint, this project arrived by accident effectively. MB mentioned that most consulting projects do that.

This project started in May 2001 and terminated in August 2002. It was a collaboration between a marketing expertise organisation (RCL) and a design and engineering expertise organisation (CDP).

5.4 ANALYSIS 1: THE STORY OF THE CO-NETWORK

The following sections result from the analysis of the research questions in Part 1 of Interview Script 1 and Questionnaire 4.

5.4.1 THE ARRANGEMENT OF THE COLLABORATIVE NETWORK

MB mentioned that though the contract was started up as a normal consulting project, it ended up be more a collaboration as the project went on. This is because MB pointed JR towards venture capital funders, helping him to find and select manufacturers. MB rationalised it that: 'this became that, plus a lot of tag on bits surrounding it that won't be strictly part of the design of the product, but help move it into the production efficiently for [JR]. So it is more about the collaboration at the end.'

There was a legal contract bound for this collaborative project. CDP had set its terms and conditions. MB suggested it that, sometimes, the company working on research business gets involved with a very difficult project. The legal contract is a company protection. Plus, the company needs to renegotiate the goals and costs of projects. This collaborative project was a fix-priced contract - giving a price to do a piece of work and a list of delivery works at the end was set. It was purely money for time. JR mentioned that the legal contract was very informal because there was no legal agent involved. Before the contract was agreed, CDP and RCL discussed all details of this project. After the discussion, CDP gave RCL a proposal and explained what CDP would provide.

The essential agreement in this contract was (i) what CDP delivered and (ii) how much CDP charged. Clearly agreed before the started contract, the IPR of this innovative product belonged to RCL. From the consultant's viewpoint, MB mentioned, CDP did not own any ownership out of it because RCL came to us with its original idea. However, this agreement was not normal for an engineering consultancy because, MB suggested that a lot of consultancies hold the IPR through to the end of the project.

Moreover, MB mentioned other cases of the contract when CDP deals with other clients that:

"We do have arrangements with the clients where we are payees part of an equity sometimes. So we take equity in their companies as well as cash. ... We [also] have done projects when we have owned [IPR] to start with and we've taken an idea to people. We then engineered it and they paid us an ongoing license for the intellectual property...".

Regarding the arrangement of the contract with RCL, the whole project was split into very small pieces. At the beginning of each small piece, there was a delivered design plan of what all of the parts would be in. The review of what the next small piece would be was at the end of the previous piece and that the costs of the subsequent one would be told. MB mentioned that this contract arrangement was done along the entire RL design process.

MB suggested that this arrangement benefits both CDP and the clients. For CDP, it helps to protect the company if the innovation project was too difficult. For clients, it protects them not to upset about the charged fee if the company could not help out at the early stages. MB added that to protect this, any risky parts in the project would be put at the front end because 'the very first thing that we try to do is remove all the risk of the development'.

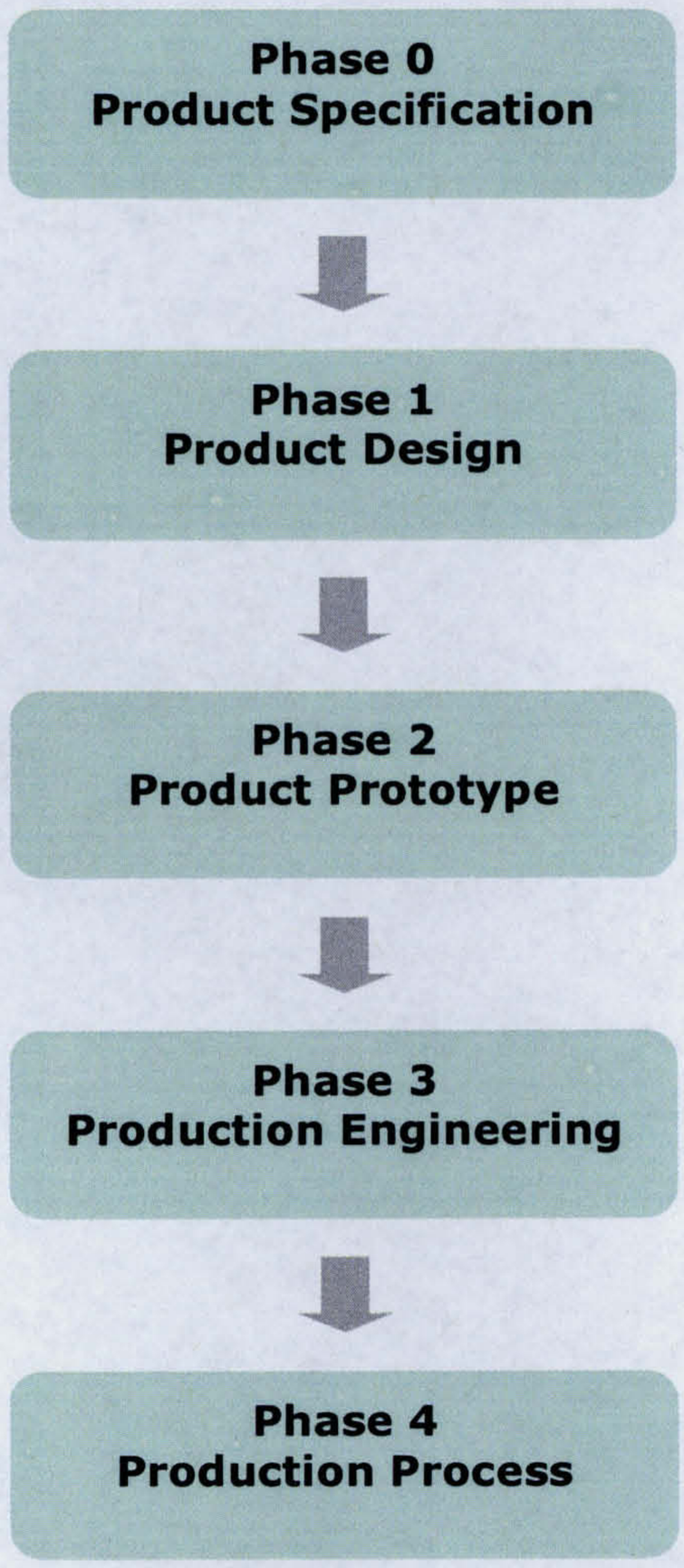
The product development process was planned by the CDP team. Nevertheless, CDP had drawn RCL to participate in this project as a part of the in-house team.

5.4.2 COLLABORATIVE PRODUCT DEVELOPMENT PROCESS

X was responsible for the product development process plan. X was the key contact during the selling work, such as scoping and costing the work, finalising the specification, and writing the proposals.

Generally, this process was mainly related to the method of the consultancy contract fee, dividing it into small pieces, as mentioned in Section 5.4.1. In this project, it comprised five main phases, as shown in Diagram 5-2:

Diagram 5-2 illustrates the collaborative product development process



Phase 0

In Phase 0, Product Specification, the aim was to write a product specification. From the consultant's viewpoint, RCL had a clear objective to produce a remote controlled light. However, RCL did have only an objective, but not the design specifications. MB believed that an innovative product specification, objective and/or concept are the bare bone of the project. It is very important to be pinned down and to be ensured that it is agreed right at the beginning with the client. At this phase, as a result, both organisations discussed and pinned these down before moving to the next phase by face-to-face conversation.

Phase 1

This phase, Product Design, was used to deal with de-risking potential difficult problems, and to design the whole characteristics and systems of the innovative product. MB mentioned, this phase is about de-risking the whole process. High risk problems would be put in this phase. X mentioned this phase was divided into two parts. First, there was a 'feasibility study' which developed a few concepts for the product and gave an outline costing. The proposal for this phase was well-defined and the work delivered on-time and on-cost. The relationship was initially rather formal, based on accepted work arrangements. X asserted that it worked well. Secondly, the major part was the product development itself. This was also initially well-planned, but there were changes in the brief as the project progressed that caused delays and overspend. The relationship became less formal and more flexible, although in some ways this contributed to the scope-creep. At the end of this phase, alternatives of industrial design, a list of product features, and requirement specifications of the product, were presented.

Phase 2

In Phase Two, Engineering Phase, the aim was to engineer a designed product into a prototype that worked fully. This phase was concerned with both technical

and physical aspects of the product, such as product mechanics, details of product assembly, production process, and material choices. Moreover, manufacturers were selected. The prototype was built on their obtainable capabilities.

Phase 3

Phase Three, Production Engineering, was the process to engineer the product prototype into the production stage. This phase involved clarifying every assembling part of a product into the manufacturing process. For the RL, the issues, such as checking the tolerance of mechanics, adjusting a designed part to be produced in the real tool, checking the tolerance of product components and building up more prototypes for product safety testing were in this phase. This phase dealt directly with the selected manufacturers.

Phase 4

Phase Four, Production Process, was to make sure that there were no problems during the production process. This phase is called, 'hand holding the manufacturers', MB mentioned. Problematic issues that may come out during this phase include tooling problems and/or technical production problems.

For this project, both teams worked from Phase Zero to Three. In Phase Four, CDP worked for RCL depending on the request.

Focusing on design aspect, two main parts were very important for the RL: product engineering design and product appearance design. Generally, both organisations would work together, and RCL could contribute input mostly to the appearance design. CDP was responsible for the engineering design. As JR mentioned:

"The engineering was also very important and I am an engineer by profession. ...I felt more like; these guys were better than I was doing it. ... where if I intervene too much I might push them in the wrong direction."

This is because the right appearance was a value judgement. Also, on the major part of the project, CDP had to add on other detailed product specifications, such as a number of handsets, lights, software, sort-code and manufactures.

5.4.2.1 THE ARRANGEMENT OF THE COLLABORATIVE PRODUCT DEVELOPMENT PROCESS

During the collaborative design and development, as mentioned above, CDP planned the project and worked on it. Within this project plan, there were different proposals that CDP needed to work on. Also, there were a number of interim meetings. These meetings were formal, on-purpose, spread around six weeks apart. Apart from the formal meetings, MB mentioned that CDP tried to have a telephone conversation with clients once every week. This regular telephone call gave RCL updated information related to the project. Also, any problems, suggestions and concerns were asked. This would keep clients on track with the project. MB described:

"We are always just very straightforward if we have a problem, we just ask [JR] or tell [JR]. ... quite often the people we are dealing with ... they're often from marketing or some other background. They might have seen something else which we haven't seen."

The nature of this process, from the consultant's viewpoint, was flexible in between the phases. Also, each phase was flexible. The investigation within each phase depended on the concerns that had arisen in the previous phase. The concerns for investigation in each phase were agreed upon by both parties. After

finishing the recent phase, CDP would redefine the working details of the next phase, and put them in a list of the deliver works - based on mutual agreement. As MB reflected on this process: 'usually, we start off with the plan right through to the production. But, the further away from the beginning it is, the more vague it becomes. And then as you work through, you just firm up each section.'

At the end of each phase, as MB mentioned, it is very formal. For example, at the end of Phase One, a list of the delivered works said three prototypes would be delivered and a set of drawings would be on CD. CDP must make sure all the delivered works were there at the end because the finished parts needed to be signed off and RCL needed to pay the bill. Then the next phase would start.

On the other hand, from the client's viewpoint, this process was informal and flexible. It was well-planned at CDP. JR mentioned that RCL did not plan the collaboration. RCL followed CDP's process. As JR mentioned:

"I didn't plan [the collaborative process]. So, the collaboration wasn't planned. They just got on with their work. ... when they needed answers on something, they sent an email or rang up. Then when there were some things that needed a meeting and then I went to see them."

5.4.2.2 PROBLEM-SOLVING DURING THIS PROCESS

Problem-solving during this process depended on issues of design. From the consultant's viewpoint, as mentioned before, the engineering design was all being undertaken in CDP. As a result, the problem-solving was done within the CDP team. As X mentioned:

"All of the technical works were discussed amongst CDP's colleagues to get some peer-review. Prototype rigs were made to test ways of achieving most parts of the design before integrated prototypes were made."

The industrial design was led by CDP. CDP did brainstorm with RCL when the design needed to be chosen. X described this process in which JR pulled in his colleague for a design brainstorming. The chosen design was initially suggested by that colleague. X mentioned further that that chosen design was embodied into the overall design process.

From the client's point of view, the most interesting part of the collaboration was when the project hit a serious problem. There was a serious problem about the light, when the product was in the production process, that it did not point where it was wanted. This problem came from a little spring in the mechanics of this designed light. RCL and CDP spent time working together to solve this serious problem for about three months. JR suggested that this problem could be solved by a software solution. Because JR pushed CDP towards this solution, CDP spent time working on it, and at the end it did not work. Finally, the problem was solved by using a mechanical solution. After this problem, the collaborative team sat down and discussed how they could avoid this problem again. As JR mentioned:

"...we agreed, if we have a problem like that again we will, everyone will, everyone will sit down ... and say, OK, we all have the problem, let's all discuss it and find out what the answer is before we start doing any work."

5.4.2.3 DECISION-MAKING DURING THIS PROCESS

In any decision-making, X mentioned that:

"Whenever there was a particular problem, I would generate a brief document (usually an email) describing the problem and a list of ways to solve it, with the pro's and con's and usually a recommendation."

Two main issues were significant in this process. First, regarding the appearance design, RCL was involved in great details because this related to a marketing aspect. JR mentioned:

"Well, in the case of the aesthetics: I am very fully involved in all conversations and looking at each option and decide which options we [are going to] go for in the end … I had no hand in choosing the microprocessor which then will be used on the printing circuit board. I am very happy with the decision which was taken, but … I was not consulted in that."

Secondly, X described the engineering design process that: '[CDP] would discuss it at length with [JR] and then decided the way forward. Sometimes this involved some more prototyping work, sometimes not.' The decision-making concerning the engineering design was based on CDP. RCL had no input. From RCL's viewpoint, JR did not need to have agreement on every thing. JR mentioned that trust and faith were very important on the process of decision-making. JR added further that, 'so that to work, you have to have a huge amount of trust and faith.' This is because CDP charged their works on the time basis, which JR has to trust them when they said and did, because it is hard to monitor.

However, X emphasised the decision-making that: 'At the end of the day, we were working for [JR], so his decision was final. However, in reality there were very few (if any) cases where our recommendations were not adopted.'

During the interview, JR reflected that there were engineering design problems which JR did not take so much time to monitor during the collaborative project. JR mentioned that it turned out that a one-sided decision was not a good decision because it wasted a lot of money and time. JR suggested that, any design issues should be got involved with, not just only working together on the appearance design, but also spending times critically assessing the engineering design.

To sum up, this case study suggests that joint decision-making is a significant part of the collaborative network.

5.4.3 COMMUNICATION

Both informal and formal communications were used during the collaborative network. For formal communication, RCL went to meet the CDP team at Cambridge for a face-to-face meeting once every six weeks. Any formal documentation, such as proposals, specifications and part drawings were released. For informal communication, emailing, telephone conversations and very occasionally written communications were used. These methods were used as required. X mentioned: 'I would have several conversations with [JR] each week –either email or phone, sometimes lasting a long time, to make sure that [JR] knew what we were doing and we didn't go up a blind alley. This worked well.'

Both organisations reflected the flow of communication as follows:

From RCL's Viewpoint

JR mentioned that emailing, verbal communication and face-to-face communication are absolutely vital. These methods allowed the collaborative team to talk to each other. Particularly, the use of email was good because it

meant there was a written record of the decisions made and the details of correspondence. JR reflected that the arrangements of communication methods were effective. Any problems cannot be recalled.

From CDP's viewpoint

Regarding MB's viewpoint, both informal and formal communications were effective and no problem occurred. Particularly, MB emphasised that the regular informal communication is very important because the project would go off-site and might be out of reach the client's expectations and needs. MB reflected from his experience in communication with other collaborative networks that the key factor is keeping communicating with the client's team. This is to make certain that everybody working in the partner team does not get out of touch with the project. MB also indicated that communicating with different groups within the client's collaborating team is very important, 'ideally verbal or even better if it is in person.' MB mentioned an example of a collaborative project between CDP and a USA company where the language was a problem during the collaboration i.e. the misunderstanding of words during verbal communication. Therefore, it is necessary to have face-to-face communication because all written, verbal and visual language can be used to solve the word-misunderstanding problem.

To sum up, both organisations had effective methods of communication during the collaborative network.

5.4.4 INFORMATION EXCHANGE

All information related to the collaborative project was openly shared by both parties. Both organisations reflected in information exchange that:

From RCL's viewpoint

All significant information related to work were shared totally, sharing the understanding of marketing needs and expectations. However, JR's commercial decision on this innovative product had not been discussed. JR reflected the issue of information sharing towards the partner that: 'I have never felt that they were concealing anything from me. I am sure, like everyone, there were things that they did not tell me.'

JR also indicated significant information of this product that, in the past, remote controlled lights have not succeeded or really taken off because it is either too expensive or too complicated to use. Therefore, the marketing issue, human factors (price), the actual method of control and product interface and ergonomics needed to be investigated.

From CDP's viewpoint

X mentioned that, sharing information –the design and the status of the project with JR was very open. X pointed out that 'honesty is the best policy.' X described the reason that open information sharing allowed problems to be brought up at an early stage. Also, MB added upon X's point that everything basically related to the project, good or bad or something that was going wrong and probably would take more time we shared out. However, MB mentioned that confidential information about the company was not shared, except in that it was published in the public domain.

5.4.5 RELATIONSHIP

Both parties agree that good interpersonal relationship towards 'friendships' between the main points of contact was significant for the successful collaborative network. Both parties reflected on this issue that:

From RCL's viewpoint

JR mentioned: '...all these things are about human relationship. Human relationship is hugely important.' The relationship between JR and X was very good and more towards friendship. If any kind of personal issue came into the project, JR believed that the engineering solution would not be very good. JR also suggested that it would be very difficult to have very productive collaboration if the main points of contact did not like each other on a personal level. JR reflected that if the personal relationship does not go so well, 'we would have designed the worst light.'

JR also mentioned that he had a close relationship with almost everyone within CDP's in-house team because, 'I respected them as individuals and respected their opinions.' The interesting point is, from his observation, that the establishment of good relationships with them was based on respect of their abilities. Moreover, JR emphasised that the role of the relationship comes to play when the collaboration is informal and flexible way.

From CDP's viewpoint

MB mentioned that building up relationships with clients is very important, especially good personal relationships. The type of personal relationship, either friendship or professional-relationship depends on a personal chemistry level. MB also reflected on another project related to this issue; CDP had one project which had been managed by a senior person in the company. The client contacted MB and said, I just personally cannot get on with this guy and if we will carry on that it will not work. As a result, MB suggested somebody else to run the project. MB suggested that good personal relationships significantly support the success of collaboration. It is absolutely key to the company because it is really difficult to find new clients, therefore the company needs to make sure every existing client will come back to work with us. From X's point of view, a good personal

relationship is key to long-term collaborations. In addition, X mentioned that it builds up professional respect for each others' abilities and also supports the ease of working together when discussing on minor issues.

5.4.6 ADAPTABILITY

From each organisation's viewpoint, both parties need to adapt to each other to optimise their own company benefits and effective collaboration. RCL particularly needs to adjust itself to CDP. Both parties reflected on this issue that:

From RCL's viewpoint

JR mentioned that there were two things that he needed to personally adapt for this project to make the collaboration effective. The first point is how to work productively with the partner. JR mentioned that, during the project, he needed to travel to meet the CDP team in Cambridge when necessary. The second point is how to deal with delays and problems. JR reflected that, as a client when working with a professional company, charging the client effectively on daily basis, if delays or problems were happening, the biggest threat that the company could do would be to stop working with them. However, instead of imposing such a threat, JR mentioned: '[I tended to] try to be nice to them and try to understand things from their point of view and try to solve things in a very friendly and relaxed way.'

JR commented on his act that 'I am not quite sure, whether in fact that was a right thing to do.' JR suggested that, because of the nature of the consulting engineering contract which is not a fixed-price contract for the entire project, the client was in a very difficult situation.

From CDP's viewpoint

X mentioned that, at the beginning of the project the company needed to adapt itself to the client's requirements. Because of the company's attitude, the company could tailor a more flexible programme with lower prices compared to other engineering consultancies. Also, during the collaborative process, the whole project plan needed to be adjusted because there was changed specification to add value to the innovative product. However, during this process, MB mentioned the CDP team did not need to adjust or adapt anything when they collaborated with JR because the nature of this project is similar to other clients' projects.

To sum up, adaptability does play a significant part in this collaborative network, from the client's viewpoint. However, this case study suggests both organisations do not need to be equally adjusted.

5.4.7 TOP MANAGEMENT SUPPORT

Both organisations reflected on this issue during this project:

From RCL's viewpoint

JR mentioned that there was no strategic plan for this project. Because RCL is a small organisation, the management support and encouragement had not been thought about. However, as mentioned before, JR determined to make this product a success by investing his own money (see Section 5.3.2.1) and adjusting himself for the project (see Section 5.4.6).

From CDP's viewpoint

From X's viewpoint, the company support was available as required –from informal chats over lunch to more formal design reviews, because the company is small. MB added the managerial opinion that the management of the organisation as a whole is based on mindset, 'keeping clients happy and informed.' It is about

communication. The support on the collaboration is a key to the company. It is the company approach. Therefore, MB asserted that the company does not really give a support because everybody does it automatically.

To sum up, both organisations are committed to this project in their own ways. For this project, there are no special supports from the Top Management of both organisations.

5.4.8 INNOVATION CULTURE

Both organisations reflected on this issue that:

From RCL's viewpoint

As mentioned in Section 5.3.3.1, JR was only one working on this project. During this project, an in-house team was employed, including three full-time engineers and two part-time artists. However, the in-house team were not involved in the collaborative network. They worked in the product fabrication –receiving different parts from the manufacturer in China and then modifying and/or assembling all parts together. Also, they tested the finished products before being sent out. JR mentioned the company had a 'very informal' working environment. All Staff know one another very well. As Managing Director, JR gave freedom for everyone to do anything that they think was right. JR tried to listen and understand staff as people rather than as employees.

From CDP's viewpoint

As a part of the in-house team, X mentioned that the in-house working culture was 'fairly innovative'. For instance, X said 'the first part of the project was a brainstorming. This was to think of the things we could do with the technology that we definitely needed and to see if there were any extra things we could do 'for free'. Although this made the product specification more complex, I am

convinced that this also greatly improved the final product.' From the managerial opinion, MB pointed that here the organisation culture allows staff to be slightly diverse because, sometimes, it would turn thing to be interesting. MB mentioned this culture related to this RCL project that, it was an interesting project because the end product specification was not in the original product specification plan. The in-house team was encouraged to think out of box all the times –whether it was on our project or the client project. MB mentioned further that the working culture in CDP was very informal. Everybody could find their suitable time to work. They knew each other very well. Within the in-house team, MB asserted, there were weekly project meetings. The meeting was for everybody who worked on the project. The meeting was to check the plan and made sure everybody was happy with what they were doing and nothing hit a horrendous problem. Moreover, MB stated that the company had a policy to give a budget for staff who wanted to develop their viable ideas based on their expertise and interest into interesting products. Staff could form a working group to develop new products based on the company's main interest, such as putting Bluetooth devices into the different products/systems. MB indicated that the organisation culture of innovation is a key. It supports the success of collaboration. MB mentioned this point that clients should end up hundred and ten percent of what they want the end product.

To sum up, there is no clear evidence suggesting that the innovation culture of both organisations support the successful collaborative network. However, CDP suggests its innovation culture is the key, leading to the successful collaboration with clients.

5.4.9 PROBLEMS/CONFLICTS DURING THE COLLABORATIVE NETWORK

Both parties agree that there were no problems and conflicts on the whole collaborative process. However, there were some problems related to technical and appearance design. Both organisations reflected on this issue:

From RCL's viewpoint

There is no problem during the collaboration, as JR mentioned 'all people [at CDP] are people who I relate to them very well.' The real problem came from the difficulties of the engineering design. There was a mechanical design fault of the RL. The problem was the accuracy of memorising positions: when the light was memorised to turn 90 degrees on the left and turned back to 180 degrees on the right. The set position of the light was not accurate. It missed 3-5 degrees in each direction. Also, there was a minor disagreement on the product's appearance. CDP suggested a new, original appearance. However, JR believed that there was a concept in product design, which is 'personality'. CDP suggested an appearance design which had a strong personality. However, JR disagreed and preferred the design with 'neutral personality'. This is because if the light had a strong personality, all other chains from hotels to retailers might not want to use it because it might convey their identity. JR stated that the problems working with CDP during the collaboration were not really difficult in comparison with understanding the real market:

"I think it is hard to understand how reluctant people in the real world are to use technology. The things are getting better and better. But people do not read the manual. It has got to work out of the box first time and the buttons have got to be intuitive. And that has been a problem."

From CDP's viewpoint

From X's viewpoint, there were some problems with 'scope-creep'. These were partly due to a very strong desire to please the client which caused us to suggest improvements to the product specification without fully understanding the implications that these would have on the development timetable. This was to develop the product to be a more radical design –both a more interesting mechanical and industrial design. From the managerial viewpoint, MB mentioned we wanted to do a more interesting mechanical and industrial design which is cylindrical design or pipe-like design. After JR tested the pipe-liked design with the main customers, however, he decided to pin down on a box-liked design because the customers would find this product too far reaching.

Also, there were some changes to the specification made by JR, as X mentioned:

"There were some changes to the specification made by [JR] that, with hindsight, should have changed the product architecture considerably. Because many of these changes were made a long way into development, and therefore without the possibility to re-design from scratch, the final product ended up being designed mainly to meet the initial spec and only partially the enhanced one."

X stated that even though both time and cost of this project was overrun by around 20 percent, the overall project was satisfied because the initial proposal was well scoped.

5.4.10 SUGGESTIONS TO IMPROVE THE COLLABORATIVE NETWORK

Both organisations suggest what would have been done to improve this collaborative network.

From RCL's reflection

JR mentioned that because he is too enthusiastic, too optimistic about products, many things are viewed as great and good and would be transferred. JR suggested that the company would have got an in-house team who had a critical view on the project, testing every single thing that CDP produced, and monitoring every stage during the product development process. This is because there was a design fault in product functionality. This caused a waste of time and money, and customers' dissatisfaction with the company performance. Also, JR wanted to change the structure of the project contract. It was slightly one-sided because the consultant can make mistake out of mistake and does not need to take any responsibility. JR suggested that the project contract should be a fixed-price contract. The contract should not be adjustable depending on the result of each stage during the collaborative project. JR described an example that if it subsequently turns out that consultants had made a design mistake, JR would like them to do that bit of work, not unpaid, but at very much lower rate than when they did original design. JR described the reasons that this is because (i) the remedy of work is not difficult and (ii) they should pay penalty for getting things wrong.

From CDP's viewpoint

From X's reflection, he would spend more time assessing each change in specification. This could have prevented time-overrun, budget-overspend and some design problems in its early stages of the development process. From MB's reflection, MB would have wanted to introduce 'product management' -the management of product after it went into the production for this project. Because there was a big issue of a technical design fault: the back-lag of the light mechanics which the client found it before CDP knew about it. MB mentioned:

"...so we were busy working on another, the second generation product ... and lost the plot of it, on keeping an eye on what happened with this. So, during the collaboration we would not keep closely, close enough to inform what problems will be thrown up. ...That's not good because you end up with the next product. ...So not only did we end up with the problem in here needing fixing, we actually end up with problems in the next product... And we could have avoided it. ...It's easier to fix them from day one."

As a result, MB mentioned there were more parts put into new design, which increased the product cost. Because cost is critical to the development of any innovative product, the company tries to avoid exceeding the product specifications.

As reflected above, there was a technical design problem which both parties had not realised until the designed product had gone through the production process. Each organisation suggested different perspectives to avoid that problem during the collaborative product development process. From the client's viewpoint (RCL), there should have been a critical review of the in-house team at each stage. From the consultant's viewpoint (CDP), the project leader should assess each change in design specification. Also, the consulting service of Product Management during production process should be introduced. Both agree that preventing any design problems can save product cost and decrease the time of the process.

Moreover, the RCL raises the ethical issue regarding the consulting fee and the consultant responsibility of the fault in the designed product. Regarding the consulting fee of this project, it was separated into different small fixed-price contracts moving along the development process, instead of one fixed price

contract for the whole project. The small fixed-price contracts correlated to the period of the project. From the client's viewpoint, the client would prefer one fixed-price contract for the whole project. In this case, because there was a technical design fault and the client needed to pay for the consultant's mistake. From the consultant's viewpoint, CDP argues that becoming involved with the project of designing innovative products is full of commercial risk. Design errors and mistakes may happen. The different small fixed-price contract is of mutual benefit for both client and consultancy. As CDP indicated on the collaborative development process, mentioned in Section 5.4.2, if the client project is not feasible at the Phase Zero, they will not need to pay a big amount of money for an unachievable project. At the end of the interview, JR was asked: 'do you think it is necessary for doing this kind of collaborative project?' JR replied that 'that's a kind of approach that you probably have to take.'

5.4.11 CONCLUSIONS

Analysing the research information in Part 1, some important factors during the successful collaborative network are revealed as follows:

1. GOOD INTERPERSONAL RELATIONSHIP

Both parties agree that a good interpersonal relationship, especially between the main points of contact across organisations, is very important. From the client's viewpoint, it supports 'productive collaboration' and has an effect on the quality of design solutions. Because it relates to personal communications, decisions, and interactions, as JR said, the designed product would be worse if personal relationships are not good. Also, the personal issue, people's abilities, supports good relationships. The consultant said that personal issues – personality and personal chemistry, have an effect on personal relationships. As a result, having incompatible personalities between the main points of contact could cause damage to the collaborative project because good interpersonal relationships could not be built up. The personal chemistry could elevate the type of personal relationship from good interpersonal relationship to close, long-term friendship. Moreover, a good interpersonal relationship is a key to long-term collaborations, both in terms of mutual respects of abilities and the ease of working together when discussing on minor issues.

2. AGREED LEGAL CONTRACT

CDP sets up the legal contract. From the consultant's viewpoint, the goals and the benefits (costs and IPR) need to be clearly identified at the beginning. The proposal and the project plan need to be set up. The project plan is a guideline which is not fixed. It is adjustable along a collaborative product development process. In this case, this process was led by CDP. The arrangement of payments in the legal contract relates to this process. It is divided into each small section of

work. After finishing each, the review will be done in order to readjust the next piece of work and the payment. Both parties share similar opinions and agree that the legal contract does not underpin the success of the collaborative project. In CDP's opinion, it helps to deal with things when something goes wrong and is not very successful. In RCL's point of view, once the contract was agreed, it was ignored through the rest of the project.

3. A FLEXIBLE COLLABORATIVE PRODUCT DEVELOPMENT PROCESS

In general, the collaborative product development process is informal and flexible. This process is well planned within CDP. However, each phase needs to be adjustable. At the Phase Zero, the process was formal. Once the project had moved along to Phase One and Two, the process became less formal and more flexible. Both parties agree that to deal with the collaborative development of innovative products, the process needs to be flexible. Firstly, the collaborative team needs to be adjustable on uncertain or changing issues, such as improving design specifications and adjusting design aim, which may improve the better end result of the innovative product. From RCL's viewpoint, clarity of the aim was not really an issue. At the beginning, the aim of this product was very clear. Once this process had moved along, the aim was adjusted because of the value-added recommendations for innovative products. From the CDP viewpoint, at the beginning, the aim of the project was essential, especially as the design specification needed to be pinned down. However, along the route of this process, there are other beneficial functions which might be added on the product to add product values. As a result, though design specification, suggested by CDP, at the beginning is concerned as essential, RCL reflected it needs to be adjustable along the development process. To sum up, because the nature of collaborative product development process, it is unlikely that this process would have a clear, well-defined process because it is full of uncertainties and very difficult.

4. JOINT PROBLEM-SOLVING

Problem-solving during the collaborative product development process depends on the issue. The technical design problem was mostly solved within the in-house CDP team. The industrial design was done by both organisations. However, the most interesting point that emerged from the client's reflection, was when the first innovative product hit the serious problem during the production process. After that problem, both organisations agreed that working together is the best way to work out problems.

5. JOINT DECISION-MAKING

During the collaborative product development process, any decisions were referred back to RCL, either technical design or industrial design. If there were any design problems or issues that RCL needed to decide, CDP would make suggestions and ask RCL's opinions about them. Most of the decisions on the technical design were based on CDP. RCL generally provided regular feedback. Regarding industrial design –product appearance, RCL played a main part in making decisions. In short, it was not a joint decision-making during this process. However, RCL reflected after finishing this project that joint decision-making is very important for some significant issues. As JR mentioned, a one-sided decision was not always a good approach to make a decision. If the decision was wrong, it would waste a lot of time and money.

6. MONITORING THE COLLABORATIVE DEVELOPMENT PROCESS

According to JR's reflection, RCL should monitor and be involved in significant issues related to innovative products. In this case, the client experienced a problem of technical design. JR mentioned that it was an erroneous idea to have very loose monitoring on the consultancy doing the decision-making.

7. TRUST

From JR's viewpoint, trust and faith were necessary during the collaborative process because RCL invested a huge amount of money and could not monitor everything when CDP said. Especially, trust had to be placed on CDP's decision-making. In this case, to sum up, the issue of trust allows the consultancy to make autonomous decisions based on its experience (technical design) in the collaborative project. Trust allows the connection and interaction with each other. Trust allows one organisation work with others. In short, trust was critical at the beginning and during the collaborative project.

8. EFFECTIVE COMMUNICATION (METHODS)

Both parties agree that the arrangement of both effective formal and informal communication is absolutely vital. From RCL's viewpoint, written, verbal and face-to-face communications are essential. From CDP's viewpoint, communicating with different groups within the teams, ideally verbal or even better if it is in person, is significant. It helps everyone in the team to express their thoughts, concerns, suggestions and experience and to increase creativity towards innovative products. Particularly, the constant integration of regular informal communication, such as telephone conversation and emailing is critical. Effective communication keeps the project on-track and supports the project to achieve the client's expectations and needs.

9. OPEN-MINDED AND HONEST INFORMATION SHARING

All information related to the collaborative project was openly shared between both parties. RCL shares its marketing information. CDP shares any information related to technical and industrial design. From CDP's viewpoint, open communication between the collaborative team is significant. The collaborative team needs to communicate openly in any issues that they concern related to the

project, such as sharing any suggestions, concerns, existing information and problems. Open-minded, honest communication is the best action. MB mentioned that clients have different experience so they could give some solutions.

5.4.12 REFLECTIONS

Regarding the interview, both organisations were very open-minded. They reflected on every aspect regarding their experience of this project. Both parties understood their mistakes and reflected on their strategy to deal with future collaborative projects.

Turning to the point of other interesting issues, the outstanding issue regarding this collaborative project is the compatible quality of organisation attitudes towards their organisation management and the activities of innovative products:

RCL, The Client and The Initiator

The role of RCL in this collaborative project is the client and the collaborative project initiator. JR reflects a deterministic attitude and commitment, which is having a great interest in an innovative idea, towards the development of innovative products. JR employs a personable approach which is reflected in the management of both the internal activities and interactions and connections with the collaborative partner. As mentioned in Section 5.4.7 and 5.4.8, the management of the internal structure and activities is a very informal and personable approach –treating the staff as people rather than solely employees. During the collaborative product development process, as JR was investing his own money, JR preferred to take decisions based on his enjoyment. JR believed that this attitude to the project could be an economic and mechanistic approach to get product quicker and at a smaller price. However JR emphasised that I

might have 'a miserable time'. Also, JR tried to understand mistakes or problems from the collaborator's viewpoint.

CDP, The Consultant and The Collaborator

CDP is the consultant and the collaborative project collaborator. The consultancy has a great service mind attitude and the culture to see things in production, as MB mentioned. The company supports and pleases clients over the contract. At the beginning, the contract was started up as a normal consulting project. However, it ended up to be more a collaboration as the project went on, and included matters such as suggesting the client for venture capital funders and helping it to find and select manufacturers. MB applies this attitude and culture to the organisation's approach to both internal activities and external partners. For internal activities, the management of internal structure and working processes is very informal. There is an embedded culture of innovation, to encourage staff to form an interest group to develop their interesting viable ideas. During the collaborative process, the company's Managing Director believes that clients are collaborative partners. As a result, open-minded, honest communication is the major concern. The client needs to be openly and honestly communicated with in all issues. The company's Managing Director believes that these approaches will support the company's growth, through word of mouth, because, as MB mentioned, all our works come by recommendations.

To sum up, at the organisational level, an organisation mindset (attitude) shaped up by Top Management is vital. It reflects organisation culture –such as the concept of a working process, the management of the organisation, and the structure of the organisation. Because of the size of both parties, (small enterprises), they are compatible in their informal working process and a non-hierarchical structure. Also, each party tries to understand the other parties' problems, situations and feelings. From the client's viewpoint, JR tries to

understand delays and problems from the consultant's viewpoint. From the consultant's viewpoint, MB tries to keep clients happy and informed. The study convincingly suggests that an organisation mindset to set up a culture of innovation is significant to the successful collaborative network in the development of innovative products.

5.5 ANALYSIS 2: IDENTIFYING CRITICAL FACTORS

The following sections result from the analysis of the research questions in Part 2 of Interview Script 1 and Questionnaire 4. Three main categories of the critical factors are as follows:

5.5.1 WITHIN THE COLLABORATION

From the analysis of all answers (please see Table 5-1 in Appendix 5) from the direct, open-ended question, *'what were underlying critical factors in the collaborative team across organisations which underpinned the success of new product collaboration? And why?'*, eight critical factors are identified. One is agreed by both organisations:

(1) Good interpersonal relationship

Other seven factors are individually mentioned:

(1) Communication (CDP's viewpoint)

(2) Complementary skills and knowledge (CDP's viewpoint)

(3) The understanding of other partners' problems (CDP's viewpoint)

(4) Well-defined collaborative goals (RCL's viewpoint)

(5) Collaborative attitude -Mutual understanding of each other problems and/or needs (RCL"s viewpoint)

(6) Abilities of the partner to share their expertise and make decisions based on their expertise (RCL's viewpoint)

(7) In-house efficient resources to appraise the partner's work (RCL's viewpoint)

5.5.2 WITHIN EACH TEAM/ORGANISATION

From the analysis of all answers (see Table 5-2 in Appendix 5) from the direct, open-ended question, *'what were underlying critical factors in your team and organisation which underpinned the success of new product collaboration? And why?'*, the following critical factors are identified by each organisation:

(1) Friendliness (CDP's viewpoint)

(2) Being approachable by clients. The clients can express concerns, thoughts and complaints (CDP's viewpoint)

(3) A clear brief for each individual in the team (CDP's viewpoint)

(4) In-house regular meetings in the team (CDP's viewpoint)

(5) Top Management determination and commitment, including the determination to make the project a success and financial support (RCL's viewpoint)

(6) Good abilities of in-house team in production and testing the product (RCL's viewpoint)

5.5.3 BETWEEN THE MAIN POINTS OF CONTACT

From the analysis of the answer (see Table 5-3 in Appendix 5) from the direct, open-ended question, *'Regarding your role as a main point of contact between your partner and organisation, what was your critical contribution that made the collaboration success?'*, the following critical factors are identified by each organisation:

(1) Being approachable by everyone in the collaborative team (CDP's viewpoint)

(2) Being a friendly and efficiently contact point (CDP's viewpoint)

(3) Understanding of each in-house team member's abilities (CDP's viewpoint)

(4) Effective facilitator – to guide the in-house team and to explain the project issue to the collaborative partner (CDP's viewpoint)

5.6 ANALYSIS 3: THE ASSESSMENT OF KEY FACTORS

The following sections result from the analysis of the research questions in Part 3, *'Please identify how critical the following indicators were which underpinned the success of new product collaboration and give me your reasons to support any answer.'* Please see the research outcome in Table 5-4 and the analysis of the value of the level of mutuality of each key factor in Table 5-4.1 in Appendix 5. The assessments of the value of the key factors in my hypothesis and the level of mutuality of each key factor are derived from the views of the main points of contact. MB's assessment is used as supportive information.

The outcome of the analysis of the value of all key factors in my hypothesis is listed in Table 5-5 below. Based on the identified critical factors, they tend to have high level of mutuality between the collaborative organisations.

Table 5-5 reveals the value of each key factor

VALUE	KEY FACTORS
Critical	**Between the main points of contact** • Trust in the abilities of each other between the main points of contact (MA) • Openly sharing information (MA) • Good interpersonal relationships • Effective communication, especially effective informal communication between the main points of contact **During the collaborative process** • Clear, well-defined collaborative objectives (MA) • Joint decision-making concerning new product during design process • Commitment of the collaborative team across organisations
Important	**Between the main point of contact** • Good working relationship with your partners' team **During the collaborative process** • Your in-house team's adaptability (MA) • Well-planned collaborative product development • Joint problem-solving concerning new product during design process • Effective communication between the collaborative team **Within the team/organisation** • Innovative abilities of your in-house team (MA) • Innovation culture of your organisation • Top management commitment and support

Remarks: MA means agreed in the value of each key factor between X and JR.

5.7 SUMMARY OF CRITICAL FACTORS

Please note; the results of the analyses in Section 5.4 – 5.6 are cross-analysed. Please see the outcomes of all key factors from three Sections in Table 5-6 in Appendix 5. Critical factors are summarised by categorising key factors of all three sections into different, relevant units (please see the details of the research analysis method in Section 3.8.2). Critical factors in three main groups and their reasons are:

□ BETWEEN THE MAIN POINTS OF CONTACT

1. GOOD INTERPERSONAL RELATIONSHIPS

Both organisations agree that good interpersonal relationships between the main points of contact and good relationships within the collaborative team are critical. This case suggests that this factor benefits the collaborative network as follows: (1) to support the collaborative organisations to talk openly about problems and how to resolve them, (2) to build up partners' confidence, (3) to help the collaborative organisations to work together easily, (4) to support productive collaboration, (5) to support the quality of design solution, (6) to promote long-term collaboration, and (6) to strengthen mutual respects of abilities of each other.

2. OPEN INFORMATION SHARING

Both parties agree that open-minded, honest information sharing, in particular between the main points of contact is critical. This case suggests that information should be openly shared in any issues related to the product –suggestions, concerns, existing information, and problems. This factor benefits the collaborative network as follows: (1) by reducing any problems during the collaboration, (2) by flagging up problems quickly (3) to give feedback to the collaborative team in order to make them work properly, and (4) to add up the level of trust.

3. EFFECTIVE APPROACH OF COMMUNICATION

Both organisations agree that both formal and informal approaches of communication need to be in place for the whole team, especially the integration of effective informal approach of communication (as needed) between the main points of contact. An informal communication approach is, for example telephone conversation and emailing. This case suggests that it is better to let

communication happen between the main points of contact, not for the whole collaborative team. This means the direction of communication should go through the main points of contact. This factor helps the collaborative network as follows: (1) to protect the collaborative project going off track, (2) to keep update and monitor the project, and (3) to be a basis for successful collaboration.

4. MUTUAL TRUST IN EACH OTHER'S ABILITIES

Both organisations agree that trust in the abilities of the partners is critical, particularly mutual trust between the main points of contact. On the one hand, RCL also adds that trust and faith need to put into the collaborator's team. On the other hand, however, CDP asserts that trust in the abililites at the organisational level is less critical because there was no share long-term benefits. This case suggests that trust should be in place at the beginning and throughout the collaborative process. Trust helps the collaborative network as follows: (1) by supporting the confidence, and (2) by allowing open connections and interactions with each other.

5. ADAPTABILITY

Adaptability between the collaborative team is important. From RCL's viewpoint, RCL needs to adapt to the consultant because the company has different methods of working. From CDP's viewpoint, CDP needs to adjust the project plan to changed specification to add value on the innovative product. This case suggests that adaptability supports the effective collaboration.

□ DURING THE COLLABORATIVE PROCESS

6. CLEAR, WELL-DEFINED COLLABORATIVE OBJECTIVES

Both organisations agree that the collaborative objective/goal has to be clear and well-defined at the beginning of the project. This case suggests that the clear goal should be set up to state what the collaborative project wants at the outset

and what would be achieved at the end. In this case, innovative product specifications have to also be pinned down because RCL has only a creative idea but no specifications. This factor should be the fundamental factor in the collaborative network. This case also suggests that without clear objective, problems may occur, such as over budget spending.

7. FLEXIBLE APPROACH DURING THE COLLABORATIVE PRODUCT DEVELOPMENT PROCESS

Both organisations agree that a collaborative product development process should be flexible. This case suggests that this process should be well-organised for the whole process. However, it needs flexibility and informality during each phase along the process. Also, this case suggests that, at the outset, this process is formal. However, this process becomes more flexible and informal when the develop project moves along. This is because the nature of innovative product development projects. There are unavoidable, uncertain or changing issues during the development process. This case suggests that flexibility during the development process would improve the end result of innovative products and thrive 'creativity'. It also facilitates value-added recommendations which would increase the value of innovative products - adding beneficial functions on innovative products without increasing cost in production process, and/or introducing some smart solutions which might be useful for other similar designs.

8. CLEAR AGREEMENT OF THE BENEFITS

Both organisations agree that the collaborative benefits should be agreed between the collaborative organisations at the fundamental/negotiative level before the legal contract will be signed. This case suggests that the significant agreed benefits include shared benefits and intellectual property rights. The benefit of this factor is to help to prevent problems which may happen if the project fails.

9. COLLABORATIVE ATTITUDES OF THE COLLABORATING ORGANISATIONS (MUTUAL UNDERSTANDING ATTITUDES)

Both organisations share a similar view that the collaborative organisations should have basic understandings of problems and adapt to different requirements between each other. One tries to understand others, based on others' viewpoints, problems and/or intentions. In this case, RCL understands the nature of the consultant's problems which can arise when involved with engineering design. In the same way, CDP understands what the client needs – represented on service attitudes. Regarding the study reflection, collaborative attitudes are based the organisation ethos. This case suggests that mutual understanding between the collaborative organisations facilitates and optimises effective collaboration as a whole.

10. JOINT PROBLEM-SOLVING

Based on RCL's viewpoint, joint problem-solving when working on serious problems during the development process is critical. In this case, there was a mistake based on the RCL suggestion on solving an engineering design problem. As a result, it causes time and money wasting. RCL suggests that this factor would help to prevent problems getting worse and initiate new ideas.

11. JOINT DECISION-MAKING

Both organisations agree that joint decision-making is critical. In this case, CDP makes decisions on technical design, based on its specialised knowledge. RCL jointly makes decisions on industrial design. However, the client reflects that, on some key issues, a one-sided approach is not always a good approach to make a decision. As a result, if a one-sided decision is wrong, it will waste time and expense.

12. COMMITMENT TO THE COLLABORATIVE PROJECT

Both organisations agree that commitment of the collaborative team to the collaborative project is critical. Such commitment facilitates the project progression and contributes to the result of good innovative products.

☐ **WITHIN EACH TEAM/ORGANISATION**

13. TOP MANAGEMENT COMMITMENT AND SUPPORT

Managing Directors of both organisations agree that Top Management commitment and support from each organisation towards innovative products is critical. From RCL's viewpoint, financial support is vital. It allows the project creation and the detemination to make the project a success. From CDP's viewpoint, organisation culture is a key concern. It creates an organisation mindset to support the project and also maintains the company operation and expansion.

14. EFFICIENT IN-HOUSE ABILITIES

Both organisations share a similar view that each in-house team ability should have their specialised expertise and knowledge. Apart from that, JR reflected that RCL should have got an in-house team that has efficient abilities to monitor the CDP team during the collaborative project. JR asserted that this would have helped to prevent design problems. From the consultant's viewpoint, MB asserted that the in-house team should be friendly and easily approachable. This is because it helps to build up the clients' confidence and allows clients to express their concerns, thoughts and complaints. My study particularly focuses on innovative abilities of each in-house team. This case suggests that, from the consultant's viewpoint, innovative abilities of each in-house team is vital at the beginning of the project. However, it is less important when the project is progressing.

15. INNOVATION CULTURE OF ORGANISATION

Managing Directors of both organisations agree that an innovation culture in each organisation is critical. From the consultant's viewpoint, it stimulates the client's excitement and enhances the client's confidence. From the client's viewpoint, it is a key to gain market share and lead the company success.

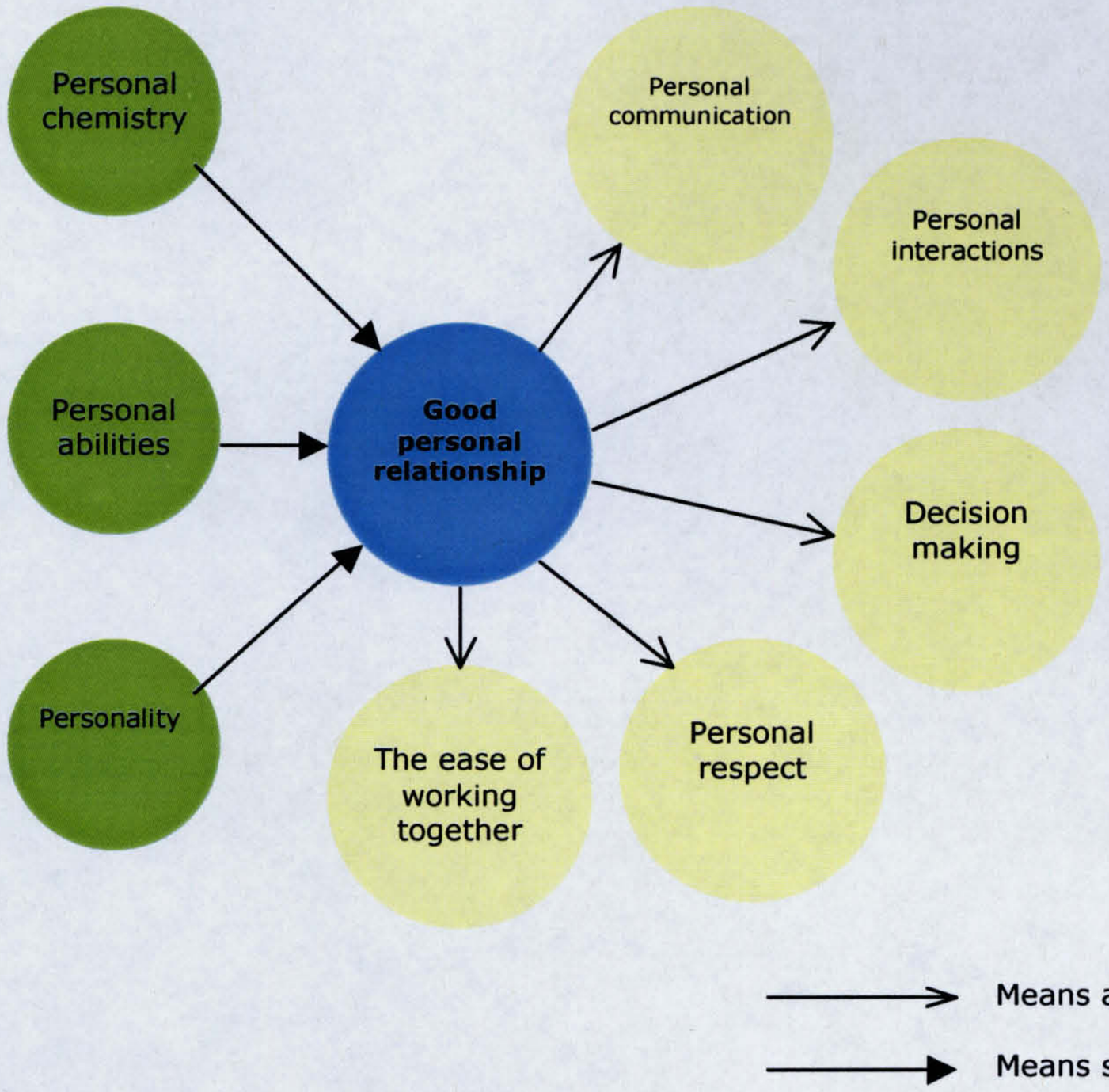
5.8 REFLECTIONS AND COMMENTS

Focusing on the collaborative networking before this project was started, the negotiation between the collaborative organisations was based on demand-supply relations. All benefits were agreed before the legal contract was signed. At the negotiation stage, connections, interactions and communications were rigid and formal. Once the development project started and moved along, a personal relationship between the main points of contact starts building up. Connections, interactions and communcations become less formal and more flexible.

Three research participants reflect many key factors and aspects strengthening the successful collaborative network in the development of innovative products. For instance, first, most of the key factors are related to each other. The relations between personal relationships and other factors during the collaborative network is shown in Diagram 5-3.

Secondly, of particular interest, my study focuses on the level of mutuality. This case suggests that the mutuality is vital. Most of the critical factors tend to have high level of mutuality between the collaborative organisations. The mutuality between the collaborative organisations is percieved as equality, reciprocity, and similarity.

Diagram 5-3 illustrates the relations between personal relationships and other factors



As mentioned in Case study 1, thirdly, attitude, behavioural and communication aspects of the collaborating participants and organisations are significant. Case study 2 support this point suggesting that these key aspects emerge to be dominant, especially in maintaining the effectiveness of the collaborative, multidisciplinary network, such as mutual trust, mutual understanding, good interpersonal relationship, adaptability, flexible innovation process, open sharing information, effective communication and Top Management commitment and support.

Fourthly, there are other underlying important suggestions which are clearly reflected from this case: (i) the significant role of the main point of contact and (ii) the compatability between the collaborative organisation mindsets. Regarding Case Study 1, the main point of contact plays an absolutely vital part in the

connections and interactions between organisations. As shown in Case Study 2, the evidence suggests the main point of contact has to also perform many tasks and responsibilites during the collaborative project:

(1) Adapting the communicative language

(2) Building up both good personal and working relationships

(3) Being able to communicate well

(4) Being a friendly and efficient contact point

(5) Being an efficient mediator between internal and external teams

(6) Respecting the other collaborating teams' abilities

(7) Understanding others' distinctive roles

(8) Communicating openly and honestly

As a result, the responsibilities of the main point of contact appear to be a key point of concern for collaborative success. Secondly, the second important point is the compatability between the collaborative organisation mindsets. This point is based on the similarity of the organisations' mindsets, such as organisation's attitudes towards innovative products, organisation culture, organisation structure, and management style. As shown in Case Study 2, this point has been reflected upon. My study assumes that this point would be another key point.

In conclusion, all added-up points which this case study reflects: the attitude, behavioural and communication aspects, the role of the main point of contact, and the compatability of organisation mindsets, will be observed in Case Study 3.

APPENDIX 5

Table 5-1 reveals all answers of three research participants who mentioned underlying critical factors within the collaborative team which underpinned the successful collaborative network in the development of innovative products

INTERVIEWEES	CRITICAL FACTORS	REASONS
MB (CDP)	1. Communication	Na
	2. ♦To make sure that our design team does not compete with the client's in-house design team which has similar expertise.	It can be quite negative and not useful.
X (CDP)	1. The complementary skills and knowledge.	CDP had no knowledge of the market that the product was being designed for, but a good understanding of product design and manufacture. JR had the market knowledge, so the skill balance was good.
	2. The understanding of other partners' problems.	In this case, JR had a good enough understanding of engineering to understand the problems that CDP came across.
	3. Good personal relationship	To talk openly about problems and how to resolve them
JR (RCL)	1. A clear goal of what the project wanted at the outset and what would be achieved at the end.	Na
	2. Relationships	Na
	3. Attitude of both parties	Consultants needed to have a service mind and ethos: being attentive to clients and to make clients feel that the consultant cares about the work. Clients need to understand humans have faults and that consultants would get things wrong. That does not mean they are bad.
	The abilities of the consultant, especially technical abilities of the consultant and its ability to understand what to consult on and what to get on.	This means consultants need to consult clients on their specialised expertise/knowledge. They should make decisions on their specialised expertise/knowledge.
	In-house efficient resources	To appraise the consultant's work

Remarks: ♦ means this factor is experienced from other collaborative projects

Table 5-2 reveals all answers of three research participants who mentioned underlying critical factors within the team and organisation which underpinned the successful collaborative network in the development of innovative products

INTERVIEWEES	CRITICAL FACTORS	REASONS
MB (CDP)	1. Friendliness	Na
	2. Being approachable	Clients can express their concerns, thoughts, and complaints. It helps clients build up their confidence.
	3. ♪Helping clients to invoice the constancy fees regarding their yearly budget accounting.	It is the company strategy to please clients.
X (CDP)	1. A clear brief for each individual in the team	Na
	2. Regular meetings between everyone	To make sure the team was moving in the same direction.
JR (RCL)	1. The determination to make project success	Na
	2. The financial resources to invest	Na
	3. Good abilities of in-house team in production and testing the product	Na
	4. The commitment to make the project happen	Na

Remarks: ♪ means this factor is experienced from other collaborative projects

Table 5-3 reveals all answers of three research participants who mentioned underlying critical factors as the main point of contact which underpinned the successful collaborative network in the development of innovative products

INTERVIEWEES	CRITICAL FACTORS	REASONS
MB (CDP) as Project Manager	1. Being approachable to everyone within the collaborative project	To make sure the project run smoothly
	2. Openly and honestly communicating: Don't hide any problems or achievement during the project	To protect the problems getting bigger.
X (CDP)	1. A friendly, efficient contact point	For JR to get in touch with
	2. a good understanding of what each team member was capable of	Na
	3. Sufficient technical knowledge of the different parts of the project	To guide my co-workers and explain any issues to JR
JR (RCL)	There is no in-house team involved in the project at the beginning. JR is a team leader and the main point of contact. As a result, the answers in this question are similar to the answers in Table 5-2.	

Table 5-4 reveals the assessment of key factors which underpinned the successful collaborative network in the development of the innovative products

KEY FACTORS	INTERVIEWEES			REASONS
	MB	X	JR	
1. Good interpersonal relationship with your partners' main points of contact	5	4	5	MB: If it did not work, let's find another project manager quickly. It helps clients build up their confidence. X: A good personal relationship makes the hard times easier and the good times better JR: na
2. Good working relationship with your partners' team	4	3	4	MB: RCL had no in-house team involving with this project. For other projects, to understand their strengths to avoid 'the problem of not invented here.' To involve clients' team in the project to protect the negative attitude towards our team. X: JR was more senior and had the right to cancel work at any time, but the relationship was based on what each party could bring to the party JR: He believed that the main point of contact was the key person to work on the whole project.
3. Trust in the abilities of the partners	3	5	5	MB: Both organisations did not have joint benefits. If it is a joint benefit, it becomes 'critical' because it is a key to the long-term income. X: Especially when things didn't go perfectly this is very important – a "safe pair of hands" can be very comforting. JR: It supported the confidence of the project.
3.1 Mutual trust in the abilities of the collaborative team across organisations	-	4	-	X: This is something that grows (hopefully!) as a project runs, but you can never trust someone fully when you have only just met them.
4. Well-planned collaborative design process	3	4	3	MB: It needed to be well-planned, but it needs to be flexible because the nature of the project is unpredictable. Therefore, design and development process should be adjustable/ flexible along the process. X: Easy to measure progress JR: Design and development process of innovative products could not be planned in advance. It needed to start up with best intention. The collaborative team cannot spend a long period of time to plan the whole process because design and development process of innovative products would not work in this way.
4.1 The flexibility of collaborative design development process	-	3	-	X: Can cause problems, but a flexible approach is more likely to produce the desired result

KEY FACTORS (Continued)	INTERVIEWEES			REASONS
	MB	X	JR	
5. Joint problem-solving concerning new product during design process	3	3	4	MB: It helped to initiate new ideas. X: - JR: It depends on the project issues. There was no point to jointly problem solving if the partners did not have knowledge or expertise in specific issues related to innovative products.
6. Joint decision-making concerning new product during design process	3	3	5	MB: Both organisations did not involve in absolutely every little decision in the project. It depended on the project issues. X:- JR: The company must have a right to jointly make decisions on the project issues which related to its own knowledge or expertise.
7. Effective communication with your partners' team	5	-	2/3	MB: The project would go off track completely. The whole project is really the whole communication issue. JR: It was so much better if you do not communicate with them.
8. Effective communication with your partners' main points of contact	5	-	5	MB: The project would go off track completely. The whole project is the whole communication issue. JR: Otherwise you did not have ideas what were going on in the project.
8.1 Effective informal communication between the main points of contact	-	5	-	X: The basis for successful collaboration
8.2 Effective formal communication between the main points of contact	-	4	-	X: More for contractual reasons, still very important
8.3 Effective informal communication within the collaborative team across organisations	-	4	-	X: Very important internally and also with JR
8.4 Effective formal communication within the collaborative team across organisations	-	3	-	X: Limited to proposals and specifications
8.3 Ability to communicate well by the main points of contact	-	4	-	X: Saves time and thus expense
8.4 Mutual respect between the main points of contact	-	4	-	X: -
8.5 Open-mindedness between the main points of contact	-	3	-	X: Some things need to be set in stone before any work can begin – wild ideas are great, but you need to stop having them at some point!
8.6 Amicable personality between the main points of contact	-	3	-	X: -

KEY FACTORS (Continued)	INTERVIEWEES			REASONS
	MB	X	JR	
8.7 Understanding the distinctive roles of each other between the main points of contact	-	2	-	X: This was very obvious, so was never a problem.
9. Clear, well defined collaborative objectives	4	5	5	MB: The objectives had to be clear and well-defined from the beginning. However, they may change along the way. X: Critical. All of the problems that arose were results of changes in the specification (and therefore objectives) JR: How you achieve anything without knowing what you try to achieve.
10. Openly sharing information	5	-	5	MB: The problems would get bigger and bigger. JR: You share information that they need to do their job properly. It is unimportant, if some information you do not need.
10.1 Open exchange of information between the main points of contact	-	5	-	X: Adds to feeling of trust
10.2 Open information exchange of the collaborative team across organisations	-	4	-	X: Builds trust, flags up problems quickly
11. Innovative abilities of your in-house team	3	3	3	MB: The in-house team should have a mixture of both innovative people and know-how people. It is critical at the beginning of the project. As the project was progressive, it was less important. X: This product was not hugely complex, but I think that the innovative ideas we came up with enhanced the product
12. Innovation culture of your organisation	4	3	4	MB: It helps to win the project in the early stage, to get clients exciting and to make clients confident. JR: It is very important to gain market share by producing innovative products. Innovative products lead the company to be successful.
13. Top management commitment and support	5	2	5	MB: It keeps company operating and expands the company. X: I was left to run the project as I saw fit. JR: Without questions. It is extremely important.
14. Commitment of the collaborative team across organisations	4	4	5	MB: The project would not be going unless the collaborative team was committed to the project. X: You don't work weekends to get the job done if you are not committed. JR: The whole team needed to be committed. Otherwise, a good innovative product would not be created.

KEY FACTORS (Continued)	INTERVIEWEES			REASONS
	MB	X	JR	
14.1 Commitment between the main points of contact	-	4	-	X: JR was clearly committed to the project which I think inspired us all. I hope the reverse was also true
14.2 Your team commitment		4		X: -
15. Your adaptability to your partners	3	-	4	MB: Our company does not need to adapt because the company does not take shares from the partners/clients. JR: JR cannot impose his methods of working on the partner/consultant. JR had to be able to adapt to the consultant.
15.1 Adaptability between the main points of contact	-	4	-	X: Although scope-creep was a problem as a result.
15.2 Adaptability of the collaborative team across organisations	-	3		X: New problems require new skills to be brought in and learnt
15.3 Adjustment of communicative language between the main points of contact	-	3	-	X: Interesting one. I think that me learning some of the industry parlance was important, partly for contacting third parties and partly for creating a comfortable feeling with JR.
16. Your in-house team's adaptability	2	3	3	MB: This kind of project is an in-house routine. It depends on the project. If the project is out of expertise, it is extremely important to adapt or adjust to some problems. X: na JR: In-house team should participate along innovation process as it was discussed.
17. Mutual benefits of the collaborative project	-	5	-	X: Also critical but very easy to measure in this case – CDP got paid, JR got a product design
18: Mutual understanding of the distinctive abilities of the collaborative team across organisations	-	3	-	X: I think that this was more important internally to CDP
19. Your organisation structure	-	3	-	X: Few barriers, flexible

Remarks: 👍 means this factor is experienced from other collaborative projects

Table 5-4.1 reveals the analysis of the value and the level of mutuality of each key factor.

KEY FACTORS	INTERVIEWEES		VALUE OF EACH KEY FACTOR	LEVEL OF MUTUALITY
	X	JR		
1. Good interpersonal relationship with your partners' main points of contact	4	5	Critical	High (4.5)
1.1. Good working relationship with your partners' team	3	4	Important	Medium (3.5)
2. Trust in the abilities of the partners	5	5	Critical	High (5)
3. Well-planned product innovation process (during the collaboration)	4	3	Important	Medium (3.5)
4. Joint problem-solving concerning new products	3	4	Important	Medium (3.5)
5. Joint decision-making concerning new products	3	5	Critical	High (4)
6. Effective communication between the team across organisations	3-4	2-3	Important	Medium (3)
6.1 Effective communication between you and your partners' representatives	4-5	5	Critical	High (4.75)
7. Open information exchange	5	5	Critical	High (5)
8. Clear, well-defined collaborative objectives	5	5	Critical	High (5)
9. Innovative abilities of your in-house team	3	3	Important	Medium (3)
10. Innovation culture of your organisation	3	4	Important	Medium (3.5)
11. Top management commitment and support	2	5	Important	Medium (3.5)
12. Commitment of the team across organisations	4	5	Critical	High (4.5)
13. Your in-house teams' adaptability (to your partners)	3	3	Important	Medium (3)

Remarks: The value range of each key factor after the analysis: 4-5 = Critical, 3-3.99 = Important, 2- 2.99 = Little Important, 1-1.99 = Unimportant
The level value of mutuality: 4-5 = High, 3-3.99 = Medium, 2-2.99 = Low, 1-1.99 = No Mutuality

Table 5-6 illustrates the collective research outcomes of key factors from three parts

KEYWORDS	RESEARCH OUTCOMES OF PART 1	RESEARCH OUTCOMES OF PART 2	RESEARCH OUTCOMES OF PART 3
Between the main point of contact	☐ Good interpersonal relationship (MA) ☐ Effective ways of both formal and informal communication, especially informal communication (MA) ☐ Open-minded and honest information sharing (IM, CDP)	☐ Open-minded, honest communicating (sharing information) (IM, CDP) ☐ Good personal relationship (MA)	Critical ☐ Good interpersonal relationship ☐ Effective methods of communication, especially informal methods ☐ Openly sharing information ☐ Trust in the abilities Important ☐ Good working relationship
During the collaborative process/ between the collaborative team	☐ Agreed benefits in the legal contract (MA) ☐ Flexible collaborative design and development process (MA) ☐ Joint problem-solving concerning new product (RCL's Reflection) ☐ Joint decision-making concerning new product (RCL's Reflection) ☐ Monitoring collaborative design and development process (IM, RCL) ☐ Trust and faith in the abilities of the partner's team (IM, RCL)	☐ Complementary skills and knowledge (IM, CDP) ☐ Well-defined collaborative goal (IM, RCL)) ☐ Collaborative attitude –mutual understanding of each other problems and/or needs (IM, RCL) ☐ Abilities of the partner to share the expertise and make decisions (IM, RCL)	Critical ☐ Clear, well-defined collaborative objectives ☐ Joint decision-making concerning new product during design process ☐ Commitment of the collaborative team across organisations Important ☐ Well-plan collaborative design and development process ☐ Joint problem-solving concerning new product ☐ Effective communication between the collaborative team ☐ Your in-house team's adaptability

KEYWORDS (Continued)	RESEARCH OUTCOMES OF PART 1	RESEARCH OUTCOMES OF PART 2	RESEARCH OUTCOMES OF PART 3
Each in-house team/ organisation	☐ The compatibility of organisation attitude, such as management approach, organisation culture and Top management style	☐ In-house efficient resources/ abilities (IM, RCL) ☐ Top Management commitment (IM, RCL) ☐ In-house team being approachable by clients (IM, CDP) ☐ Friendliness (IM, CDP) ☐ A clear brief for each individual in the team (IM, CDP) ☐ Regularly review meeting of the in-house team (IM, CDP)	Important ☐ Top management commitment and support ☐ Organisation culture of innovation ☐ Innovative abilities of in-house team
As the main point of contact		☐ Being friendly and efficiently contact point (IM, CDP) ☐ Understanding of each in-house member abilities (IM, CDP) ☐ Effective facilitators between in-house team and external team (IM, CDP)	
As Project Manager or Managing Director		☐ Being approachable by everyone in the collaborative team (IM, CDP)	

Remarks: MA means 'Agreed'; IM means 'Individually Mentioned'.

CHAPTER 6: CASE STUDY 3

THE COLLABORATIVE NETWORK Y

INTRODUCTION TO CHAPTER 6

Chapter 5 discusses the collaborative network between RCL and CDP in the development of Remote Controlled Light. Chapter 5 identifies fifteen underlying critical factors contributing to its success. Case Study 2 suggests that most of the critical factors tend to have high level of mutuality between the collaborative organisations.

Chapter 6 describes the investigation of Case Study 3: a collaborative network between a small technology enterprise and a manufacturing-based company in the development of innovative product YY. This case study is reflected from the view of the technology enterprise. The sections are as follows:

Section 6.1 describes general details of Case Study 3

Section 6.2 details the research approach of Case Study 3.

Section 6.3 describes the background information of Case Study 3, including the general information of Product YY, background of the collaborative organisations, background of the collaborative team, and background of the collaborative network.

Section 6.4 describes the analysis of the research questions in Part 1 of Interview Script 1, focusing on the detailed story of Case Study 3. The main topics of the

analysis are: the arrangement of the collaborative network, a collaborative product development process, communication, information exchange, relationship, adaptability, Top Management support, innovation culture, problems/conflicts during the collaborative network, and suggestions to improve the collaborative network. Section 6.4 also summarises the research findings derived from the research questions in Part 1.

Section 6.5 describes the analysis of the open-ended research questions in Part 2 of Questionnaire 4, focusing on the identification of critical factors. The analysis of the critical factors is divided into three main categories: critical factors within the collaborative network, critical factors within each team/organisation, and critical factors between the main points of contact.

Section 6.6 describes the analysis of the close-ended research questions in Part 3 of Questionnaire 4, focusing on the assessment of how critical key factors in my hypothesis are and the level of mutuality of each key factor.

Section 6.7 summarises critical factors derived from the research findings of Case Study 3.

Section 6.8 asserts reflections and comments of the research findings of Case Study 3.

6.1 INTRODUCTION

My original intention was to investigate Project C which was awarded by the Millennium Product Awards. Unfortunately, the partner company of Organisation A went into liquidation. Project C was ended. During the interview, the collaborative network Y (Y) to produce innovative product YY, was given as an example of one of the other projects in which Organisation A has collaborated with other external organisations. After discussing with the research participant on Y, I decided to move my focus from Project C to Y. The research participant, AA, agreed to reveal Y's story. This collaborative project, based on a licensing agreement, was the collective action and responsibility to create YY.

However, the research participant insisted that all details and information about this project which will be published in this thesis must remain anonymous. The participant mentioned that this innovative product has not been mass-produced. It is recently in the production process. It will be launched to market at the beginning of 2005. The partner may think that we have breached the issue of confidentiality which is bound by the legal contract between the collaborative organisations. As a result, the research participant did not allow me to contact the partner.

6.2 RESEARCH APPROACH

The research participant AA from Organisation A contributed to the network case study information. Due to the circumstance of this project, the investigation of Y had to be divided into 2 phases. During the first phase, the story of Y was investigated by a structured, face-to-face interview (see the details of questions in Part 1 of Interview Script 1 in Appendix C-3). During the first interview, product YY was still in the development process. I decided to finish the interview at Part 1. After product prototype YY had been done, the rest of the questions

was sent out by email (see the details of questions in Part 2 and 3 of Questionnaire 4 in Appendix C-4). There were telephone conversations with AA after the questions were answered.

Comparing the details of key factors in my hypothesis in Part 3 of interview script 1 with questionnaire 4, there are some improvements, which included adding more key factors. Also, these factors are categorised into three groups: (i) between the main points of contact, (ii) within the collaborative process, and (iii) within the team/organisation.

6.3 BACKGROUND OF CASE STUDY

6.3.1 BACKGROUND OF INNOVATIVE PRODUCT YY

Regarding the research participant protection and research agreement, the study cannot publish any photos or specific product details of this innovative product.

The concept of this innovative product is initiated by the combination of new material technology with existing sports products. This innovative product not only improves the physical appearance, but also enhances its functionality. Users will wear this product during outdoor sports activities.

6.3.2 BACKGROUND OF THE COLLABORATIVE ORGANISATIONS

Two organisations worked collaboratively in this network:

6.3.2.1 Organisation A (Org A) is a small UK technology enterprise that specialises in new material technology. It licenses its intellectual property rights of technology to other companies. The enterprise mainly works on the experimentation to produce new conceptual pieces of innovative technology.

6.3.2.2 Organisation B (Org B) is a large USA manufacturing-based company that specialises in the design and development, the manufacture and the marketing of outdoor sports products. It is renowned as an innovative company that continuously creates innovative products. Normally, it has its own in-house Research, Design and Development team.

6.3.3 BACKGROUND OF THE COLLABORATIVE TEAM

As shown in Diagram 6-1, the collaborative team comprised two main teams:

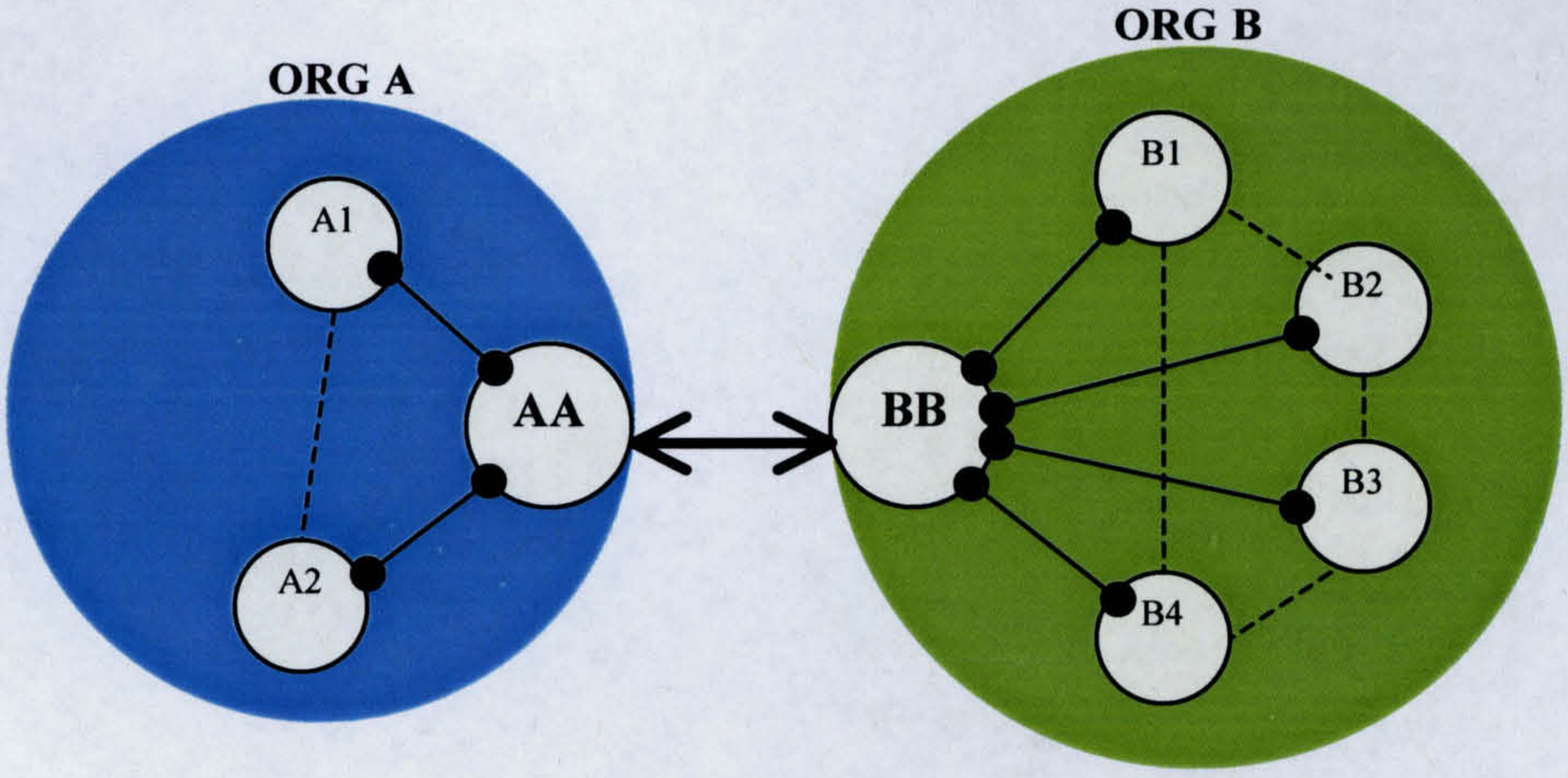
6.3.3.1 Team A was from Org A. Three persons worked for Y. AA, the Managing Director, worked as the main point of contact who connected and interacted with BB, and as an internal project manager who organised and motivated internal correspondents and distributed information. A1 was an electronic engineer and Managing Director. A2 was a production engineer.

6.3.3.2 Team B was from Org B. BB, Project Manager, worked as a main point of contact who connected and interacted with AA and as an internal project manager who distributed the right information to the right people, pulled and linked different people from different divisions to join in the project, and interacted with them. The correspondents in Org B were B1, in-house design team; B2, marketing and promotion team; B3, production team and B4, top management team.

During the collaborative project, AA closely connected and interacted with BB. AA could not have access to any Org B's correspondents, unless AA was introduced by BB. Therefore, AA had to pass all information through BB, and BB would communicate and distribute to BB's internal correspondents. On the other hand, if BB requested specific information which AA could not provide in detail, A1 or A2 would interact with BB directly. This may happen at the production stage. As AA

mentioned that if the production prototype needs specific supports from Team A, such as a particular problem about an electronic circuit board or the production of new material, A1 or A2 have to directly work with BB.

Diagram 6-1 depicts a broad overview of the collaborative team during the product development process.



These two teams contributed different expertise and shared responsibilities during this collaborative project.

Team A was responsible for the technical issues of its own material technology which was hidden in the innovative product YY, such as inspecting the product systems and details of new material technology which would be applied to aesthetic design. AA mentioned that Team A was responsible for, for example how the material had been used, how to integrate technology into the material and design, and how to analyse the properties of the material that had been used in the right conditions for sports activities.

Team B was responsible for the design and development of the aesthetic appearance – shapes, colours, choices of materials, and product functions.

6.3.4 BACKGROUND OF THE COLLABORATIVE NETWORK

This project was started at the end of 2003 by the direct contact from Org B to Org A. Org B knew Org A from joining a technology seminar. AA presented the paper on the Org A's new technology. AA mentioned that, after the conference finished, Org B had bought some product samples from Org A's website. After testing those samples, Org B contacted Org A directly and asked Org A that they were interested in developing a project.

6.4 ANALYSIS 1: STORY OF THE CO-NETWORK

The following sections result from the analysis of the research questions in Part 1 of Interview Script 1.

6.4.1 THE ARRANGEMENT OF THE COLLABORATIVE NETWORK

This project was based on a licensing agreement. Org A licensed its technology patents and know-how (the technology system) to Org B. Regarding the license, Org B needs to pay an initial fee in order to use this technology and a 'loyalty fee' for each manufactured product when the products have been produced in the production process. Also, there are other issues which are included with this legal agreement, such as the payments, commercial confidentiality and the working process. AA mentioned: 'after the legal contract is signed, the collaboration project is alive and the communication is opened up.' As a result of this legal contract, Org A possesses the IPR of the technology in the innovative product. The appearance of this product belongs to Org B.

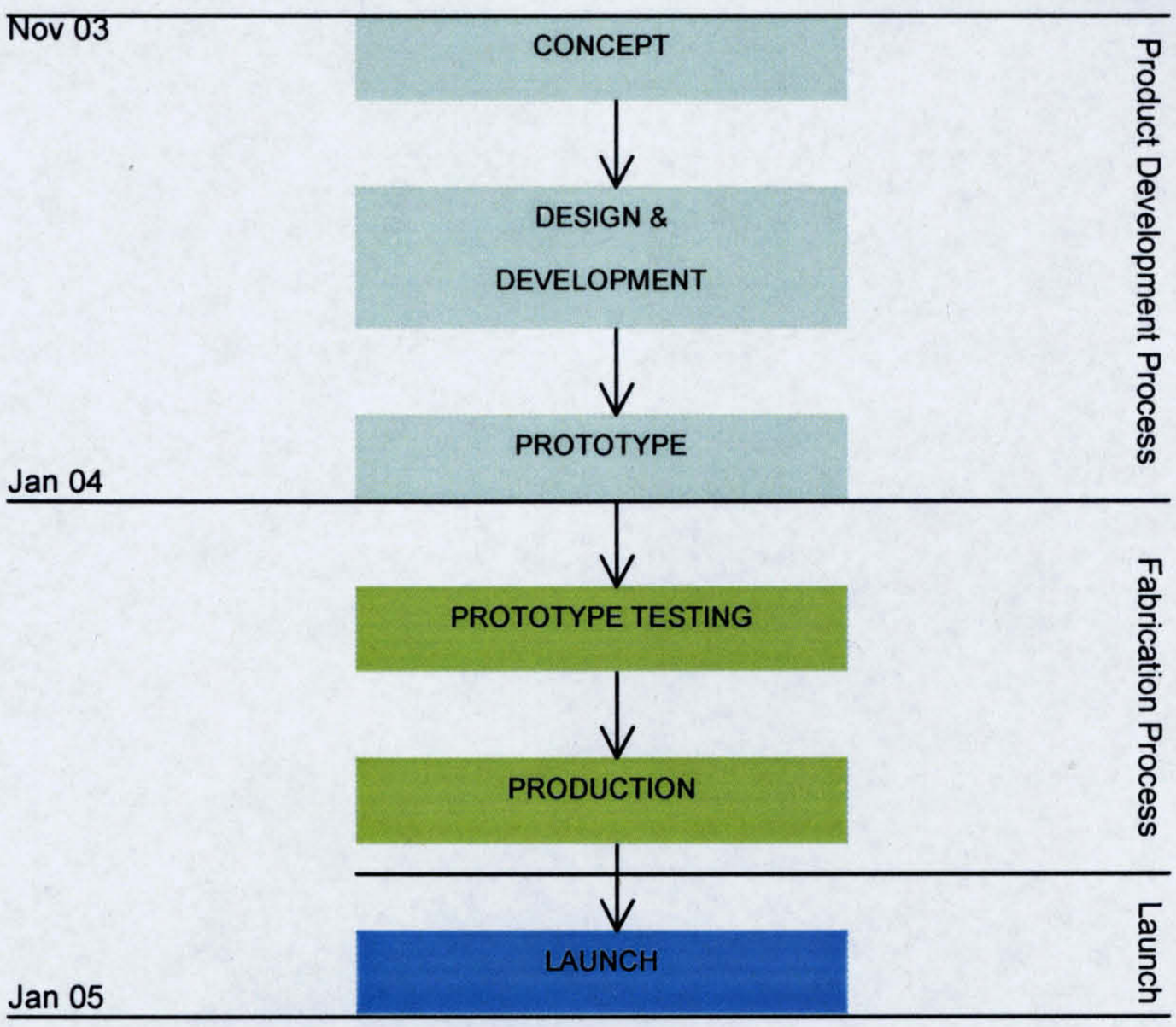
6.4.2 COLLABORATIVE PRODUCT DEVELOPMENT PROCESS

Team B planned and managed the whole collaborative product development process. BB worked as the collaborative project manager who managed both the internal and external correspondents. The whole process, as shown in Diagram 6-2 comprises three main processes: Product Development Process, Fabrication process, and Launch. In this research, two processes, Product Development Process and Fabrication, are described.

Process 1: Product Development

During the Design Concept stage, Team B initiated the product concept. Team A was brought to this project during the Design and Development phase. AA mentioned, even though Org B received technological know-how information, it still needed Org A to demonstrate how this material technology functions and is assembled.

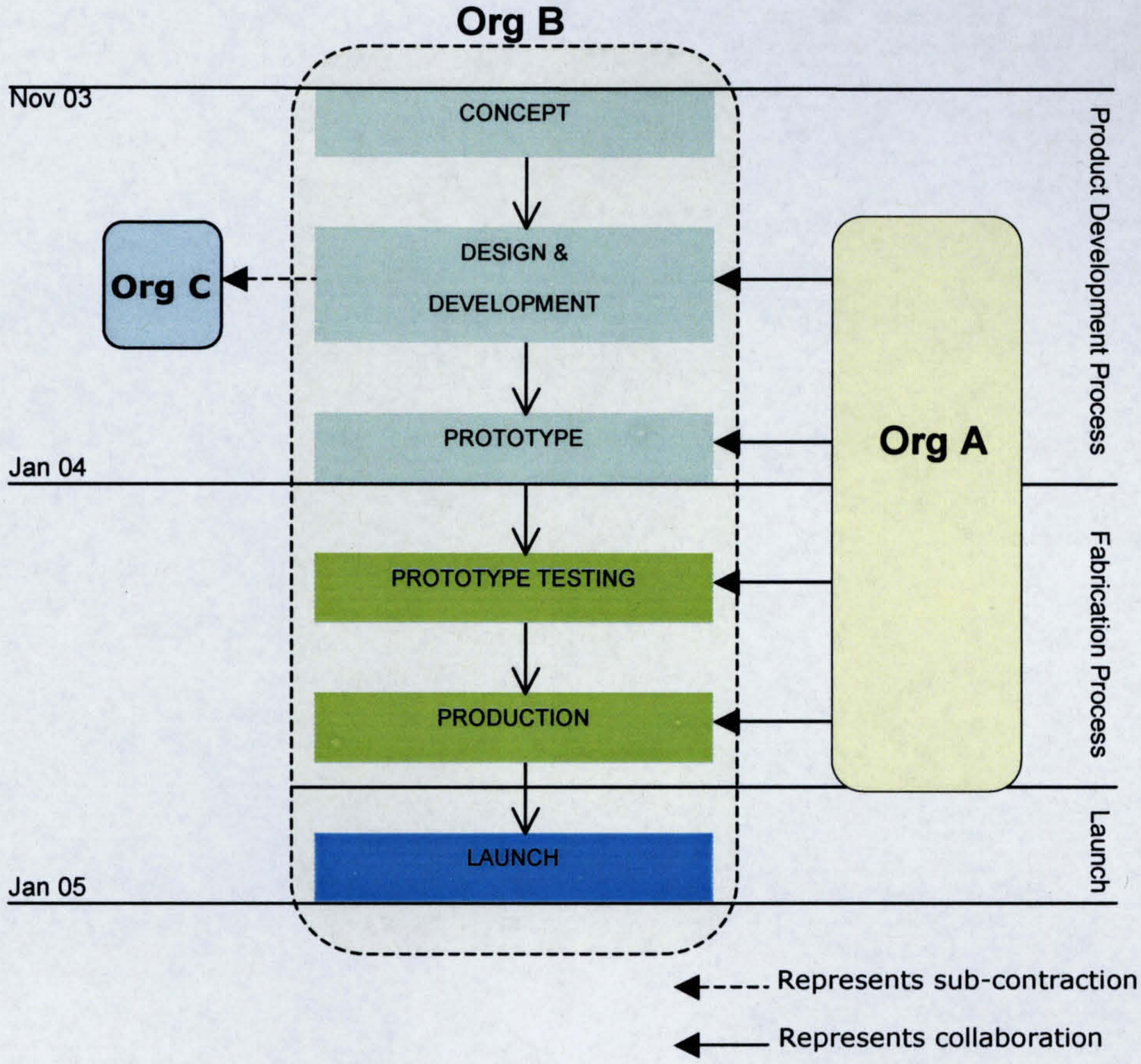
Diagram 6-2 illustrates the collaborative product innovation process



During the Design and Development phase, AA participated with BB's correspondents by sharing the technical know-how to 2 or 3 staff from the legal

department or from the sale and marketing public relations (B2). AA mentioned, everybody who involves in this process needs to understand this technology, especially the sale and marketing public relations team, because this team will not tell the wrong information about the specification of the innovative product.

Diagram 6-3 illustrates the contribution of Org A during the collaborative product development process



As AA mentioned, Team A contributed to this phase on the following issues:

- ☐ to assess how the material has been designed
- ☐ to give information support on how Team B integrated the technology system into industrial design
- ☐ to analyse on how the designed product would be suitable to use in the specific conditions of the sports activities
- ☐ to suggest the possibilities of aesthetic design which can be achieved by integrating the new material technology

Because of the project time constraints in this phase, Org B subcontracted Org C to produce a prototype of the technology system. Please see the role of Org A's contribution and Org C in this process in Diagram 6-3.

Process 2: Fabrication Process

During this process, Team A will support Team B if there is a particular problem which relates to the technology. In specific cases, Team A will send in-house experts, A1 and/or A2 to work closely with Team B. Moreover, in the Prototype Testing stage Team A needs to take responsibility in testing the product prototype because it has to offer the liability approval, the CE mark. Furthermore, in Production stage Team A needs to send in-house experts to work closely with the factory in China in order to instruct the machines and production lines.

6.4.2.1 PROBLEM-SOLVING DURING THIS PROCESS

During Process 1, Team B mainly worked on industrial designs. Both organisations worked together for solving design problems as practically as they could. As AA mentioned, during the Org B visit, AA needed to make them understand and became aware of the constraints of the new material technology because sometimes their designs are impossible to be technically achieved. In some cases, if their designs are nearly possible, AA will negotiate with Team B into the most acceptable compromise.

6.4.2.2 DECISION-MAKING DURING THIS PROCESS

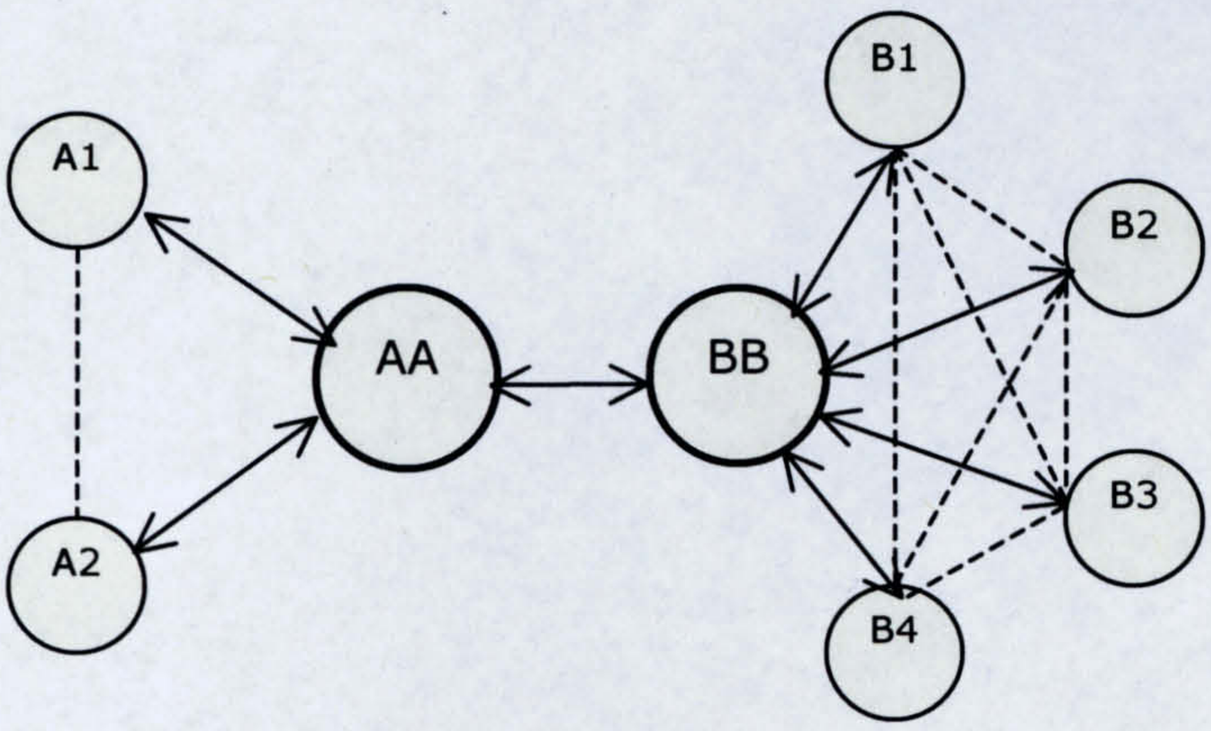
AA mentioned that Team A does not have a right to join the decision-making during the whole collaborative product development process. Team A could suggest what would be the best solution for the problems. However, at the end the decision depended on Team B. AA mentioned, this is because Team B has been granted by its organisation to take the total responsibility for the project. The final decision was made by BB. AA mentioned, because of the internal pressures and aspirations and the external technological constraints, the final

decision was based on BB, though AA can influence on BB's decision-making in some points.

6.4.3 COMMUNICATION

AA and BB closely communicated with each other. Every piece of information had to go via them, as shown in Diagram 6-4.

Diagram 6-4 depicts a broad overview of the flow of communication between the collaborative team



⟷ Represents communications between the collaborative team across organisations

--------- Represents communications within each organisation

Both formal and informal communication methods have been utilised during the collaborative development project: face-to-face meetings, visits between organisations, telephone conversation and emailing. AA mentioned that physical presence or contact, such as face-to-face meetings and organisation visits, is not necessarily required anymore. Recently, the use of emailing and digital imaging equipment has replaced them. AA added the drawback of physical presence and contact that it will slow the process down. Moreover, AA compared the communication method of emailing with telephone: contacting people on the phone is not as good as emailing because there are no records. If you want to record a telephone conversation and file it, it will be hassle. For email, you can

use it as reference. Furthermore AA suggested that verbal and written communication, such as emailing and documentation have become necessarily.

Not only are the communication methods significant, as AA mentioned, but the quality of information: clear, detailed and structured information which is used during communication is also very important. If vague, general and unstructured information is communicated, the project will not move forward and may cause project failure.

6.4.4 INFORMATION SHARING

Regarding information sharing, AA reflected that communications are very open between both organisations concerning the project. AA assumed that prior to contacting Org A for the project, Org B had already researched Org A's background. On the part of AA's organisation, AA stated that, for further information about Org A, such as draft agreements on licensing technology and how Org A runs and works with other organisations and projects, every potential or existing partner can find it from Org A's website. Org A provides an exclusive area for them to access. AA asserted that the more Org A opens itself to its parts, the more partners will support it. AA believed that this will help loyal partnerships to be established and maintained.

6.4.5 RELATIONSHIP

AA believed that the collaboration depends on 'very strong person-to-person contact'. AA reflected that the close relationship between the main points of contact is very significant for the success of the collaborative project.

6.4.6 ADAPTABILITY

From Org A's viewpoint, AA mentioned three levels of adaptability during the collaboration:

(1) On the in-house organisational level, AA needed to adapt and adjust on a daily basis. Because of the nature of a technology transfer company, it needs to be constantly changing and refining to adapt to fast changing technology.

(2) On the inter-organisational level, AA needed to adjust their use of English to communicate with Team B and learn how to communicate with them in their way of understanding. On the technical level, AA mentioned that, he does not need to adjust himself to BB so far. The adaptation or adjustment will depend on BB's level of technical knowledge.

(3) On the collaborative partner level, the role of BB in this project has to be flexible and adaptive towards external constraints and internal aspirations. These main factors are identified that BB needs to reach: i) technical constraints, ii) needs for a final perfect design and iii) Top Management's aspirations.

6.4.7 TOP MANAGEMENT SUPPORT

From Org A's viewpoint, because AA works as a leader of the company and has a great belief in technology, he therefore gives strong support and commitment to collaborative projects. As he mentioned, 'I want to see this [technology used] in every household in the world. I am chasing a dream. But I am really on a crusade.'

6.4.8 INNOVATION CULTURE

From Org A's point of view, AA mentioned that there is no organisation structure in Org A. AA works as a network organiser who connects and interacts with other external members who work for the organisation. AA claimed that the company has survived for more than 5 years because AA knows how to link all members together. Basically, this company works on the specific external demands. If there are any enquiries, AA reacts with them by himself in the workshop first. If subsequently one of the enquiries is feasible and turns to be a real project, AA organises a working group and process. AA mentioned that this working culture can respond and react instantly. Also, enquiries do not need to go through a long process within a normal organisation structure.

6.4.9 PROBLEMS/CONFLICTS DURING THE COLLABORATIVE NETWORK

From Org A's viewpoint, there have been problems and conflicts during this collaborative network. AA reflected two main problems:

1 English Language. Although both organisations share a common language, English to communicate in their everyday life, AA mentioned, AA found it is very difficult to communicate with Team B. The main problem has been vocabulary. Team B could not understand some vocabulary that AA used.

2 Information Distribution. AA has worked as information hub internally and information interface between internal and external organisations. This means, as AA mentioned, when the information comes into AA it is difficult to decide which way information will go out again and in what fashion, whether in high technical terms or very simplistic terms.

There were also initial conflicts and disagreements on basic concepts and work methods. AA said that there were expected misunderstandings on how thing were

done and procedural requirements for such things as tractability in each separate industry. These were overcome by in depth questioning of what was the right way to do things for their particular industry, and what was required to meet all tractability, administrative and health and safety requirements.

AA also mentioned how to solve them,

"For the most part it was our company that did the questioning. We saw it was necessary to take the lead and let the other participants tell us how they wanted to work and in what way they wanted things done... We were wherever possible compliant and fitted into the other participants' mode of operation. Only in extreme cases did we offer alternative suggestions for task methodology or insist on certain functions being carried out in a particular way. This would be in circumstances where we thought safety in the workplace and end product merchantability might have been compromised by doing things their way."

6.4.10 SUGGESTIONS TO IMPROVE THE COLLABORATIVE NETWORK

From Org A's viewpoint, AA suggested before the commence of the project, Org A should have done research to find out how Org B worked, what Org B made and where Org B made it. AA explained that Org A should have contacted other past collaborators with Org B and asked if they could give us any background information on Org B and Org B's methods. The reason for this would be to find out how Org B works in order to form a plan and prepare to meet Org B.

6.4.11 CONCLUSIONS

Analysing the research information in Part 1, some hidden important factors within the successful collaborative network are revealed as follows:

1. FLEXIBLE COLLABORATIVE PRODUCT DEVELOPMENT PROCESS

The collaborative development process needs to be flexible. In this case, the interaction and communication structure is constantly changed and adapted by changing external environments, such as project time limitations and both organisations' demands and expectations.

2. ADAPTABILITY OF THE MAIN POINTS OF CONTACT

The main points of contact need to be flexible and adaptive because they need to deal with constraints and demands of their internal and external factors, such as the constraints of Org A's technology and Org B's aspiration of very innovative design. Therefore, they need to be able to negotiate for the best solution. Also, during the communication, they have to adjust their language to be suitable for each other.

3. JOINT PROBLEM-SOLVING

To create the best solution when creating innovative products, both organisations need to solve the design problems together, through negotiation based on their different expertise and tensions that exist. In this case, the tensions are the constraints of Org A's technology and the Org B's aspirations of very innovative design.

4. OPEN AND EFFECTIVE COMMUNICATION

The collaborative organisations have to openly share information and communicate effectively. The quality of information has to be clear, detailed and structured. In this case, open communication and information sharing have the strong correlation with the mutual agreement within the legal contract. Informal communication is very important.

5. GOOD INTERPERSONAL RELATIONSHIP

The interpersonal relationship between the main points of contact is very significant. As AA mentioned the collaboration is dependent on 'very strong person-to-person.'

6.4.12<u>REFLECTIONS</u>

The structural link of this network is demand-supply link. This network is more than the technology licensing. Both organisations need to work collaboratively. On the Org A's part, the collaboration is motivated by the licensing agreement that, when the innovative product YY is manufactured, Org A will get both licensing fee and loyalty fee. On the Org B's part, the interaction is motivated by the finished product which will be launched in market. Therefore, the intensive collaboration between both organisations derives from mutual benefits. If Org B can launch this innovative product on time, it could open up its market opportunities as the first product in the world market and its reputation as the market leader. On the other side, Org A will get the 'licensing fee' and 'loyalty fee'. The more Org B produces this innovative product, the more fees Org A will earn.

Turning to the interesting point of Org A, as AA mentioned above, Org A has survived for more than five years because it is very flexible and can adapt itself to external demands. The company has no certain structure. The synthesis of the company structure is depended on external needs. It is organised by the Managing Director, AA. Therefore the role of AA as a company leader is vital to the organisation's survival. AA interfaces with both internal and external facets. Internally, AA has to organise, communicate and motivate both internal resources and correspondents. Externally, AA has to communicate, connect and interact with external organisations, demands and changes. To sum up, two main points

are very important for Org A's survival: the adaptable structure of the company and the role of the company leader.

6.5 ANALYSIS 2: IDENTIFYING CRITICAL FACTORS

The following sections result from the analysis of the research questions in Part 2 of Questionnaire 4. The critical factors are divided into three main categories as follows:

6.5.1 WITHIN THE COLLABORATION

From the analysis of AA's answers (see Table 6-1 in Appendix 6) from the direct, open-ended question, *'what were underlying critical factors in the collaborative team across organisations which underpinned the success of new product collaboration? And why?'*, the critical factors are:

(1) understanding of other collaborating parties' distinctive abilities

(2) understanding of other collaborative parties' drives and benefits

6.5.2 WITHIN THE TEAM/ORGANISATION

From the analysis of AA's answers (see Table 6-2 in Appendix 6) from the direct, open-ended question, *'what were underlying critical factors in your team and organisation which underpinned the success of new product collaboration? And why?'*, the critical factor is:

(1) To thoroughly understand other parties' expectations, needs and constraints in the design and development process of innovative products –to provide a right service

6.5.3 AS THE MAIN POINT OF CONTACT

From the analysis of AA's answers (see Table 6-3 in Appendix 6) from the direct, open-ended question, *'Regarding your role as a main point of contact between*

your partner and organisation, what was your critical contribution that made the collaboration success?', the critical factors are:

(1) Ease of working with others' team members –to prevent conflicts and the clash of personalities

(2) To make sure that the collaborative team strives for the same goal

6.6 ANALYSIS 3: THE ASSESSMENT OF KEY FACTORS

The following sections are resulted from the analysis of the research questions in Part 3 of Questionnaire 4, *'Please identify how critical the following indicators were which underpinned the success of new product collaboration and give me your reasons to support any answer.'* Please see the research outcome in Table 6-4 in Appendix 6. Regarding the level of mutuality, the research findings of this case study cannot be analysed. This is because there is one organisation participating in this research, instead of all collaborative organisations. However, the research findings of this section will be observed in the cross-case analysis in Chapter 8.

The analysis outcome of the value of all key factors in my hypothesis is shown in Table 6-5 below.

Table 6-5 reveals the value of key factors in my hypothesis from AA's viewpoint

VALUE	KEY FACTORS
Critical	**Between the main points of contact** ▫ Good interpersonal relationship between the main points of contact ▫ Trust in the abilities between the main points of contact ▫ Effective informal communication between the main points of contact ▫ Open-mindedness between the main points of contact ▫ Commitment between the main points of contact ▫ Equal working relationship between the main points of contact ▫ Open exchange of information between the main points of contact ▫ Ability to communicate well by the main points of contact ▫ Mutual respect between the main points of contact ▫ Amicable personality between the main points of contact **During the collaborative process** ▫ Mutual trust in the abilities of the collaborative team across organisations ▫ Effective informal communication within the collaborative team across organisations ▫ Commitment of the collaborative team across organisations ▫ Mutual benefits of the collaborative project ▫ Mutual understanding the distinctive abilities of the collaborative team across organisations ▫ Joint decision-making concerning this new product ▫ Adaptability of the collaborative team across organizations **Within the team/organisation** ▫ Innovative abilities of your in-house team ▫ Your team commitment ▫ Innovation culture of your organisation ▫ Flexibility of your team ▫ Top management commitment and support (To be continued next page)

VALUE	KEY FACTORS (continued)
Important	**Between the main points of contact** ▫ Effective formal communication between the main points of contact ▫ Understanding the distinctive roles of each other between the main points of contact ▫ Adaptability between the main points of contact ▫ Adjustment of communicative language between the main points of contact **During the collaborative process** ▫ Clear, well-defined collaborative objectives ▫ Close relationship of the collaborative team across organisations ▫ Open exchange of information within the collaborative team across organisations ▫ Well-planned collaborative design development process ▫ Flexibility of collaborative design development process ▫ Joint problem-solving concerning this new product ▫ Effective formal communication within the collaborative team across organisations **Within the team/organisation** Your organisation structure

6.7 SUMMARY OF CRITICAL FACTORS

The results of the analyses in Section 6.4 – 6.6 are cross-analysed. The outcomes of the key factors from three Sections are shown in Table 6-6 in Appendix 6. Critical factors are summarised by categorising key factors of all three sections into different, relevant units (see the details of the research analysis method in Section 3.8.2). The critical factors in three main groups and their reasons are:

□ BETWEEN THE MAIN POINTS OF CONTACT AND DURING THE COLLABORATIVE PROCESS

1. GOOD INTERPERSONAL RELATIONSHIP

A good personal relationship supports the progression of the collaborative project.

2. MUTUAL TRUST IN THE ABILITIES

Mutual trust in the abilities of each team should be embedded across the collaborative team. Org A suggests that deep research into partners' specialist field could elevate trust.

3. EFFECTIVE INFORMAL COMMUNICATION

Effective communication, particularly informal communication, between the main points of contact and the collaborative team is a core approach to deal with the collaboration. Effective formal communication (physical presence or contact, such as face-to-face meetings and organisation visits) is used for the formal issues, such as the negotiation of the contract and issuance of payments. Org A suggests that regular formal communication might slow down the process. In addition, Org A suggests that the quality of information is very important. It has to be clear, detailed and constructed i.e. know-how information and proven data. Communicating vague, general and unstructured information will slow down the project and may cause the project failure.

4. OPEN-MINDEDNESS

Open-mindedness between the main points of contact facilitates willingness to understand others' viewpoint.

5. COMMITMENT

Commitment from all levels: in-house team and Top Management; between the main points of contact, and the collaborative team is critical. Org A suggests that

the weakening partner can be encouraged by the other partner to strengthen the commitment.

6. CLEAR AGREEMENT OF BENEFITS

Before the collaborative project will be started, the benefits have to be clearly agreed by the collaborative organisations. This factor strengthens the intensity of collaboration.

7. COLLABORATIVE ATTITUDE

Collaborative attitude: thoroughly understanding other collaborating parties' distinctive abilities, drives, expectations, constraints and benefits, is critical.

8. OPEN INFORMATION SHARING

Information should be openly communicated between the main points of contact. This case suggests the strong legal document supports openly information sharing.

9. FLEXIBLE COLLABORATIVE PRODUCT DEVELOPMENT PROCESS

This product development process needs to be flexible. This process needs to be constantly adapted by changing external environments surrounding innovative products, such as time constraints, mismatched demands, both organisations' pressures, aspirations to design the superior products, and innovative design expectations. Flexible product development process helps the collaborative project to be able to reach the design deadline and produce a good quality of innovative product.

10. ADAPTABLITY

The collaborative success is based on the adaptability of the collaborative team. In this case, there are many in-house teams in Org B with which AA needs to contact. Therefore, the adaptability to the partner team is important as well as

the adaptability between the main points of contact. Org A suggests that adaptability supports the willingness to change.

11. JOINT DECISION-MAKING

This factor is critical, particularly on the level of design feasibility between end product requirements and constraints of existing technology. As mentioned above, this collaborative project is a shared knowledge between two organisations which have different expertise. There should be a compromise on design feasibility, based on both organisations' constraints and aspirations. Org A suggests that joint decision-making supports the feasibility of end product and cost constraints.

☐ **WITHIN THE TEAM/ORGANISATION**

12. INNOVATIVE ABILITIES OF IN-HOUSE TEAM

Based on the base of the Org A business, the innovative abilities of the in-house team are absolutely vital.

13. INNOVATION CULTURE OF YOUR ORGANISATION

Based on the base of the Org A business, innovative approach to business is a way to survive because all income is dependent on it.

14. FLEXIBILITY OF THE IN-HOUSE TEAM

Based on the nature of Org A management, flexibility with the team and organisation is of utmost necessity. All staff work full-time in other companies. They join each project on request.

6.8 REFLECTIONS AND COMMENTS

The critical factors of Case Study 3 have been summed up from one organisation's viewpoint, instead of all the collaborative organisations, because of

the confidentiality bound by the legal contract. It illustrates another example of the successful collaborative network in the development of innovative products from two organisations which have different expertise. It was a short-term collaborative project based on a licensing agreement. This project was started by Org B which needed Org A's know-how technology to create innovative product. This project is initially linked by supply-demand relations. The intensive collaboration is based on the mutual agreement of benefits which have been negotiated by both parties at the beginning. During the collaboration, AA has reflected on different aspects and significant factors which lead to the success, as mentioned in Conclusion above.

The level of mutuality cannot be measured in this case study regarding the limitation of accessing required information. However, I surmise from AA's reflection that mutuality is still a crucial element which needs to be embedded in most of the critical factors. AA mentioned it on the following key issues: (1) good personal relationship, (2) trust in the abilities, (3) effective informal communication, (4) commitment, (5) open information exchange, (6) adaptability, and (7) decision-making.

There are other assumptions which are revealed from Case Study 1 and 2: the attitude, behavioural and communication aspects, the role of the main point of contact, and the compatibility of organisation mindsets. First, from AA's experience and perspective, three significant aspects are still dominant because they uphold the effectiveness of the collaborative innovation network, as mentioned in Conclusion above. Secondly, it is promising evidence to demonstrate that the role of the main points of contact is vital towards the collaborative network success. Regarding all the answers in Part 3, AA mentioned a number of qualitative roles which the main point of contact needs to perform as the following:

- ☐ Being able to communicate well
- ☐ Treating other parties equally during working process
- ☐ Respecting other parties
- ☐ Being an efficient mediator between internal and external teams
- ☐ Being genial when working with other parties

Secondly, the concept of the compatibility of organisation mindsets cannot be observed from Case Study 3 because there was only evidence from Org A, instead of both organisations.

APPENDIX 6

Table 6-1 reveals the answer of AA who mentioned underlying critical factors within the collaborative team which underpinned the successful collaborative network in the development of innovative products

INTERVIEWEES	ANSWERS
AA (Org A)	1. "All participants try their best to understand the other collaborating parties' technology even though it might be completely different from their own." 2. "To understand what is the driver that makes the participants want to collaborate in the first place we need to understand where they get their return from a project."

Table 6-2 reveals the answer of AA who mentioned underlying critical factors within the team and organisation which underpinned the successful collaborative network in the development of innovative products

INTERVIEWEES	ANSWERS
AA (Org A)	1. "Being willing to see what was wanted from the project and thoroughly understanding what the end product must achieve in terms of functionality meeting price points manufacturability lead time to market development cost ongoing intellectual property ownership and protection. Only with this degree of understanding could we come close to providing the type of service/ product development that was expected from our company."

Table 6-3 reveals the answer of AA who mentioned underlying critical factors as the main point of contact which underpinned the successful collaborative network in the development of innovative products

INTERVIEWEES	ANSWERS
AA (Org A)	1. "Eases of working with the individual team members even though the matters at hand are commercial and driven both financially and technically. If there is conflict between the participants or clash of personalities then the tasks at hand become very difficult to complete and tiresome." 2. "There has to be a spirit of collaborative well-being with everyone striving for the same goal."

Table 6-4 reveals the assessment of the key factors which underpinned the successful collaborative network in the development of innovative products

KEY FACTORS	INTERVIEWEE	REASONS
	AA	
1. Good interpersonal relationship between the main points of contact	5	"This was of prime importance and as we progressed through there project this spirit developed more strongly."
2. Equal working relationship between the main points of contact	4	"Whilst there was a spirit of equality between the participants each gave way to the others superior knowledge of their specialist field."
3. Trust in the abilities between the main points of contact	5	"It goes without saying the strong element of trust was necessary, however deep research into the other participants specialist field helped elevate their opinion of us."
4. Effective informal communication between the main points of contact	5	"Very important. This was chiefly achieved by e-mail and formal letter writing was almost none existent, and mostly reserved for legal matters." "E-mail was used most extensively because of time difference involved when working with an American collaborative partner."
5. Effective formal communication between the main points of contact	3	"As stated above this area was the reserve of the legal domain and such things as contract negotiations followed this communication path."
6. Open exchange of information between the main points of contact	4	"The first document to be put into place was general confidentiality agreement between the participants. After this when contracts were negotiated and ratified a greater and more encompassing requirement for confidentiality covered the whole of the project and the product life thereafter. With these strong documents in place the pathway was set for a free and open dialogue between all parties at all levels of responsibility."
7. Ability to communicate well by the main points of contact	4	"Some team members are better communicator than others so it was necessary for the whole team to meet on regular basis to discuss past present and outstanding matters. It was very much a case from our side of each member being equally responsible for the whole project and not being afraid of checking up if a task was being dealt with in the proper manner or in a timely fashion."
8. Mutual respect between the main points of contact	4	"During the course of the project this ebbed and flowed depending on the current sate of progress. It was an important cornerstone of the project and with out reference to other participant it is felt that all parties tried to continually move things forwarded and a sense of mutual respect prevailed."

KEY FACTORS (Continued)	INTERVIEWEE	REASONS
	AA	
9. Open-mindedness between the main points of contact	5	"Yes a willingness to see the other point of view is always important we were keen to let the other participants see that we were willing to do things there way if no compromises were developed as a consequence of that action."
10. Amicable personality between the main points of contact	4	"As with mutual respect and amicable personality will always prevail over an insular one. Participants were encouraged to interact."
11. Understanding the distinctive roles of each other between the main points of contact	3	"There were no clear guidelines set before the project started and this was something of a detriment. As indicated earlier it would have been advantageous for us to have done far more research into the participants' product base and corporate background."
12. Commitment between the main points of contact	5	"Vastly important angina there was ebb and flow of this but we found that the weakening partner would gain strength and renewed commitment from encouragement by the other."
13. Adaptability between the main points of contact	3	"This seems to be a rewording of an earlier question but again we saw it a vitally important to let them know that we were prepared to do things there way if needed."
14. Adjustment of communicative language between the main points of contact	3	"I and one of my colleagues had worked extensively in the USA for a number of years and had adapted to the American use of the English language. We were both familiar with and often used Americanisms in daily speech so we fully understood that was being said to us. Our collaborators however did not have any grasp on nuances of the English language and quite often we had to back track and put what we were wanting to say into American English to gain full understanding."
Focusing on the collaborative process		
15. Clear, well-defined collaborative objectives	3	"These were not presented by either party at the commencement of the collaboration however through necessity came into place during the early part of the project."
16. Mutual benefits of the collaborative project	4	"Our pay back from the project was use of our proprietary material and commission in the form of a license fee and a royalty stream from products produced containing the material. The collaborators pay back was not only a new product to their range but also the PR value of being seen by their peers it the industry to be willing to engage in new technology at the cutting edge of development. They also used this aspect of the project to make in-roads into the market relying heavily on the results of the R&D effort in the marketing campaign."
17. Mutual trust in the abilities of the collaborative team across organisations	5	"Yes this is great importance and cannot be emphasised to strongly. Only by the efforts of all was success possible."
18. Mutual understanding the distinctive abilities of the collaborative team across organisations	4	"Each of the collaborative teams had specialist skills and the other participants realised this. There was very little overlap of skills as the participants came from very different backgrounds."

KEY FACTORS (Continued)	INTERVIEWEE	REASONS
	AA	
19. Close relationship of the collaborative team across organisations	3	"A sprit of cordiality existed throughout. Even at the low points it was realised that to keep moving forward we had to do it together and not divided apart."
20. Open exchange of information within the collaborative team across organisations	3	"As stated in the section on confidentiality, once the agreements were in place on open dialogue continued through out the whole of the project. Nothing was hidden from the other; each party was open and accountable to the other."
21. Well-planned collaborative design development process	3	"There is something that had to come about through evolution of the project and the emerging product. More up front planning would have been a great advantage and would have shortened the project time and reduced R&D cost substantially."
22. Flexibility of collaborative design development process	3	"Yes we were always willing to see the other point of view. We have adopted some of the other participants design ideas into our own new product concepts."
23. Joint problem-solving concerning this new product	3	"This occurred on a regular basis, not only within each individual team but also between the teams."
24. Joint decision-making concerning this new product	4	"The end product requirements were outlined by the other party our input could have been described as negative as we mostly racked back the ideas to make the end product more feasible, and less cost prohibitive. We tried to dampen the other parties' enthusiasm as little as possible however we often find that with a new technology the hopes and aspirations of the functionality of the proposed end product can be far beyond what is actually technically achievable."
25. Effective informal communication within the collaborative team across organisations	5	"Once more it was always e-mail that acted as the communication path. Time differences being the driving factor for this. Telephone conversation was practical nil as all members did not want to enter into an eternal round of telephone tag leaving messages for the other person to get back to them also with e-mail there is a written trail of correspondence to follow and this can be of vital commercial importance when dealing with Intellectual Property rights later."
26. Effective formal communication within the collaborative team across organisations	3	"This was the reserve of the legal stuff. The transportation and negotiation of contracts and issuance of payments etc. The system worked well. For all involved."
27. Commitment of the collaborative team across organisations	5	"Rock solid every member of the team pulled his/her weight and if a collaborative team member was falling behind there was always someone else willing to assist of give guidance if needed."
28. Adaptability of the collaborative team across organisations	4	"Willingness to change was a key factor in success."
Focusing on your in-house team and organisation		
29. Innovative abilities of your in-house team	5	"This is what we do, it is the basis of our whole business."

KEY FACTORS (Continued)	INTERVIEWEE	REASONS
	AA	
30. Your team commitment	5	"If a project is not successful then there can be no financial reward therefore it goes without saying that all efforts were made to gain success as the companies viability and even the employment status of each individual member of the team is dependent on that success."
31. Flexibility of your team	4	"Yes we are very flexible by necessity"
32. Innovation culture of your organisation	5	"The whole business is based upon innovation. All our income is dependant on an innovative approach to business."
33. Top management commitment and support	4	"For us the management team is the development team."
34. Your organisation structure	3	"All members of the team are directors of the company therefore are only too aware of the importance of doing the deal and doing the deal right."

Remarks: The value range of each key factor after the analysis: 4-5 = Critical, 3-3.99 = Important, 2- 2.99 = Little Important, 1-1.99 = Unimportant

PAGE

MISSING

IN

ORIGINAL

Table 6-6 illustrates the collective research outcomes of key factors from three parts

KEYWORDS	RESEARCH OUTCOME OF PART 1	RESEARCH OUTCOME OF PART 2	RESEARCH OUTCOME OF PART 3
Between the main point of contact	☐ Adaptability ☐ Good interpersonal relationship	No answers	Critical ☐ Good interpersonal relationship ☐ Trust in the abilities ☐ Effective communication –informally ☐ Open-mindedness (personality) ☐ Commitment ☐ Equality of working relationship ☐ Open exchange of information ☐ Ability of communicate well ☐ Mutual respect ☐ Amicable personality Important ☐ Understanding the distinctive roles of each other ☐ Adaptability ☐ Adjustment of communicative language
During the collaborative process/ between the collaborative team	☐ Agreed benefits ☐ Flexible structure of the collaborative system ☐ Joint design problem-solving ☐ Openly information sharing ☐ Effective communication	☐ Understanding of other collaborating parties' distinctive abilities ☐ Understanding of other collaborating parties' drives and benefits	Critical ☐ Mutual trust in the abilities ☐ Effective communication –informally ☐ Commitment ☐ Mutual benefits ☐ Mutual understanding the distinctive abilities ☐ Joint decision-making concerning this new product ☐ Adaptability (To be continued next page)

KEYWORDS (Continued)	RESEARCH OUTCOME OF PART 1	RESEARCH OUTCOME OF PART 2	RESEARCH OUTCOME OF PART 3
During the collaborative process/ between the collaborative team (Continued)			Important ☐ Clear, well-defined objectives ☐ Close relationship of the collaborative team across organisation ☐ Open exchange of information ☐ Well-planned collaborative design process ☐ Flexibility of collaborative design development process ☐ Joint problem-solving concerning this new product ☐ Effective formal communication
Each in-house team/ organisation	☐ Adaptive organisation structure	☐ To thoroughly understand other parties' expectations, needs and constraints in the design and development of innovative products	Critical ☐ Innovative abilities of your in-house team ☐ Your in-house team commitment ☐ Innovation culture of your organisation ☐ Flexibility of your team ☐ Top Management commitment and support Important ☐ Organisation structure
As a main point of contact	An efficient mediator between internal and external team.	☐ Eases of working with others' team members ☐ To make sure the collaborating team strives for the same goal	

CHAPTER 7: CASE STUDY 4

THE COLLABORATIVE NETWORK X

INTRODUCTION TO CHAPTER 7

Chapter 6 reports the collaborative network between a small technology enterprise and a manufacturing-based organisation in the development of an innovative product. The small technology enterprise contributes the research information and reflects underlying critical factors.

Chapter 7 describes the investigation of Case Study 4: a collaborative network X between three multidisciplinary organisations in the development of an innovative product: a design consultancy, a furniture manufacturing-based company, and a technology transfer company. The design consultancy contributes to the research outcome. The following sections are:

Section 7.1 introduces Case Study 4.

Section 7.2 details the research approach of Case Study 4.

Section 7.3 describes the background information of Case Study 4, including the general information of an innovative product, background of the collaborative organisations, background of the collaborative team, and background of the collaborative network.

Section 7.4 describes the analysis of the research questions in Part 1 of Questionnaire 4, focusing on the detailed story of Case Study 4. The main topics

of the analysis are: the arrangement of the collaborative network, a collaborative product development process, communication and information sharing, relationship, adaptability, organisation support, problems/conflicts during the collaborative network, and suggestions to improve the collaborative network. Section 7.4 also reflects two main aspects of the research findings derived from the research questions in Part 1: causes of collaborative problems and sound collaborative practices.

Section 7.5 describes the analysis of the open-ended research questions in Part 2 (see the details of questions in Section 7.5), focusing on the identification of critical factors for the success of collaborative networks in the future. The analysis of critical factors is divided into three main categories: critical factors within the collaborative network, critical factors within each team/organisation, and critical factors between the main points of contact.

Section 7.6 describes the analysis of the close-ended research questions in Part 3 of Questionnaire 4, focusing on the assessment of how critical key factors in my hypothesis are and the level of mutuality of each key factor.

Section 7.7 summarises critical factors derived from the research findings of Case Study 4.

Section 7.8 asserts reflections and comments of the research findings of Case Study 4.

7.1 INTRODUCTION

The research tasks this research presented were daunting and complex. Qualitative studies required by hugely complex systems such as innovation networks entail the management of delicate negotiations with managers whose job is to maintain excellent relations among their collaborators and to ensure that all data is kept as confidential as possible. Although I was able to elicit more useful data that I had expected, the investigation of Case Study 3 proved less satisfactory than the previous ones, for reasons of my research methodology. I nevertheless needed to include it because the research participant was willing to share the experience and detail of the collaborative project. After the analysis of Case Study 3, I decided to insert Case Study 4 in order to strengthen the final research outcome.

This project, found from the second pilot study, was the collaboration among a design consultancy, a manufacture and a technology transfer company. The study contacted a person, AA who completed the questionnaire. AA was asked to participate in a research interview for an in-depth study. Unfortunately AA initially declined to give further information about this collaborative project. AA wrote:

"Unfortunately, I am not sure that I can help you at all. Yes, I am very busy … but there are also other factors. I am hesitant to share the details of this collaboration with you because it wasn't a good experience in parts –there were significant problems along the way in aligning the multiple organisations that constituted the whole team. I would imagine that this would make the case study even more interesting for you, but for us there are perils in bringing back the past –'to open old wounds' as the saying goes. We actually believe that it's better to learn and to move on –but to keep the learning within the constituent

organisations in this case. I understand how useful this information would be to you, but the potential cost to us is significant..."

At the end of the same letter, AA mentioned:

"As a last thought, I may be able to answer some more general questions for you, but I cannot give you the names of other parties to contact to talk in detail about where and why collaboration was positive or negative."

After contacting with AA via email, AA agreed to participate in the research. However, all specific details and information must be treated as anonymous and cannot be traced back to the original source.

7.2 RESEARCH APPROACH

One person contributed to this case study information: AA, an Org A's Project Leader. There was no access to any other participants.

As mentioned above, AA eventually agreed to participate in my research. However, AA could not provide the details of the collaborating partners. I decided to carry on investigating this case study despite this setback. Even though I could not get all the information and viewpoints from the collaborative partners, I believe that one viewpoint could reflect the key factors which led to the significant problems during the collaboration. Because of AA's circumstances (as quoted above), instead of interviewing AA, I decided to revise the structured interview and sent it in the form of a questionnaire (see the details of research questions in Questionnaire 4 in Appendix C-4). This questionnaire was sent via email. Through this study, AA was contacted via email communication.

Please note: my study has developed the research questions in Part 2 in Questionnaire 4, particularly for this case because of Org A's circumstances. Instead of being asked underlying critical factors that underpinned the success of this collaborative network in the development of innovative products, the research participant is asked to identify critical factors which would contribute to the success of collaborative networks in the future. As a result, a set of three research questions in Part 2 were changed (see the details of the changed questions in Section 7.5).

7.3 BACKGROUND OF CASE STUDY

7.3.1 BACKGROUND OF INNOVATIVE PRODUCT

Regarding the research agreement, my study cannot publish any photos or mention specific details of this product.

In general, this innovative product is a computing appliance with a very specific purpose. This appliance is used in the workplace as an organising system. Currently, this product has been sold in the global market.

7.3.2 BACKGROUND OF THE COLLABORATIVE ORGANISATIONS

Three organisations collaborated in this network:

7.3.2.1 Org A is a design and engineering consultancy. It specialises in industrial and engineering design.

7.3.2.2 Org B is a furniture manufacturing-based company. It specialises in design and development, production and marketing of office furniture. It has its own in-house research, design and development team.

7.3.2.3 Org C is a digital technology transfer company. It specialises in creating information platforms from digital technologies, and licensing its technologies to other companies.

7.3.3 BACKGROUND OF THE COLLABORATIVE TEAM

The collaborative team comprised three main teams:

7.3.3.1 Team A is from Org A. AA was an in-house Project Leader and worked as the main point of contact who connected and interacted with other two main points of contact. Team A was responsible for industrial and engineering design: user interface design, industrial design, manufacturing engineering and electrical engineering. Org A was a contributor for the product definition alongside two other organisations. There were twelve people in Team A.

7.3.3.2 Team B is from Org B. Team B worked as the collaborative project leader. This team provided user and market research information.

7.3.3.3 Team C is from Org C. This team was responsible for the development of the technology.

7.3.4 BACKGROUND OF THE COLLABORATIVE NETWORK

Org A introduced this product idea, the computing appliance which would be used in offices, to Org B. Org B decided to pursue the commercialisation of this idea. The alignment of the collaborative team, including Org A, B and C was established.

7.4 ANALYSIS 1: THE STORY OF THE CO-NETWORK

The following sections result from the analysis of the research questions in Part 1 of Questionnaire 4.

7.4.1 THE ARRANGEMENT OF THE COLLABORATIVE NETWORK

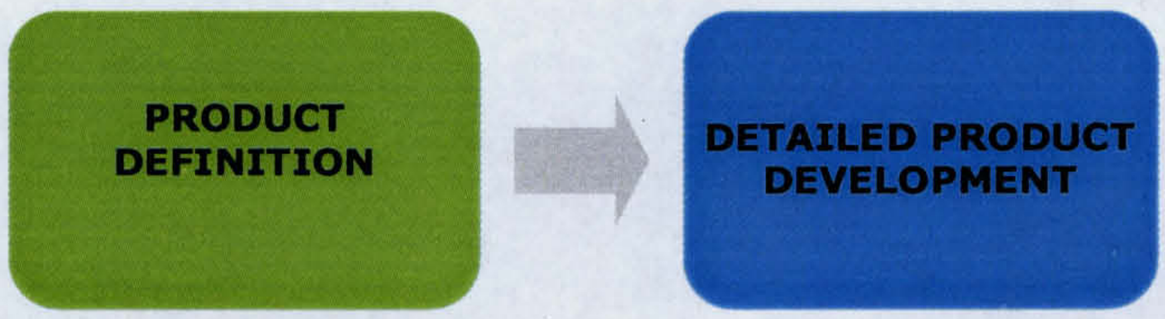
This collaborative network is bound by a legal contract. The IPR contained in the original idea were licensed to Org B, who was paying for the whole product development project. Any new intellectual properties created would be shared between Org B, who was commercialising the idea, and Org C, who developed the idea further. However, Org A had not obtained the intellectual property of this innovative product. AA reflected:

"This provides a slight flaw … because the furniture company and the technology company had different long-term goals beyond the initial product development. The technology company wanted to create a broad and robust platform that they could sell to others; the furniture company wanted to get a product into production cost-effectively and quickly. The design and development agency was working on a time and material basis, waiving all IP rights to the furniture company."

7.4.2 COLLABORATIVE PRODUCT DEVELOPMENT PROCESS

There are two main phases during the collaborative product development process, as shown in Diagram 7-1. The first phase is product definition. This product definition phase aims to explore the possible product details. The second phase is detailed product development. This phase aims to execute the possible product details. AA reflected that 'this process was not planned in great details at the early stage.'

Diagram 7-1 illustrates the collaborative product development process



During Phase 1, AA mentioned there were regular meetings between Org A and Org C, once every week, to share information and process. Org B was involved less often. When the project moved from Phase 1 to Phase 2, (the Detailed Product Development), there was no formal change in process. However, quite late in the process, Org B began to take more control.

AA reflected on this process that 'there was ambiguity regarding who was in charge' of what during the process. As a result, AA mentioned that Org C saw themselves as the leader of the project because they felt that nobody else was qualified to be in charge. Therefore, Org C drove most of the detailed process planning. On the other hand, quite late in the process, Org B began to take more control. They felt they should be in charge because they were investing for the whole project.

7.4.2.1 PROBLEM-SOLVING AND DECISION-MAKING DURING THIS PROCESS

AA reflected that during this process, the collaborative team across organisations worked through all problems and solved them together by meeting. In the issue of decision-making during this process, early in the process each organisational team made its own decisions. Later on, group meetings were organised and chaired by Org B because it was obvious that some decisions were in conflict.

7.4.3 COMMUNICATION AND INFORMATION SHARING

The collaborative team used both formal and informal communication methods. Regular meetings were the main formal communication during the collaboration.

AA mentioned that, each team member in Org A's in-house team was encouraged to communicate as needed across organisations, not just have the main points of contact communicated. Early on in the process, communication was very open. Once more disagreements emerged, the communication became less open and

the team leaders had to be involved. As AA stated that: 'this worked well when collaboration was going well, but when disagreements developed it was more important for the team leaders to be involved.'

7.4.4 RELATIONSHIP

AA described that relationships at the personal level between the main points of contact were always quite friendly. However, relationships at the organisational level were not so collaborative. AA mentioned: 'one or two people in Org C were not interested in collaboration and negotiation. They wanted more control.'

AA reflected that: 'this meant however much individuals felt they could work together, their respective organisations could never agree on the appropriate role of each organisation.'

7.4.5 ADAPTABILITY

AA described that the collaborative team needed to adapt their manners of communication. As AA reflected that:

"It is important to communicate clearly and effectively. It is important to find a common way to communicate. Each organisation prefers to communicate in a different way. To understand that you have to understand the motivations of each of the different organisations."

7.4.6 ORGANISATION SUPPORT

Within Org A, there were twelve people working for this project. The in-house team built a project space in which to share all information.

For organisation culture, Org A encourages openness, collaboration, a user-centered approach, rapid prototyping, and the role of physical space to support the team. AA believed that this culture supported the collaboration on the project.

7.4.7 PROBLEMS/CONFLICTS DURING THE COLLABORATIVE NETWORK

AA reflected two issues caused the problems and conflicts. The main issue was that there was an overlap in the responsibilities of the collaborative organisations - the roles and responsibilities were not clearly defined. Secondly, Org C was not particularly collaborative. AA commented on Org C that:

"They did not listen well to the ideas of others. As a result, when there were collective disagreements, as the project became more defined, it was hard to resolve them. [Org B] thought that they were in charge; [Org C] thought that they were in charge too."

7.4.8 SUGGESTIONS TO IMPROVE THE COLLABORATIVE NETWORK

AA reflected two issues: (1) to make clear each organisation's roles and responsibilities and (2) to make a clear project plan that supports a loose Product Definition phase and a tight Detailed Product Development phase.

7.4.9 REFLECTIONS

My study reflects two respects from this case study:

7.4.9.1 CAUSES OF COLLABORATIVE PROBLEMS

- UNEQUALLY SHARED BENEFITS

As AA mentioned the contract was slightly flawed. In this project, Org A will not receive the long-term benefits. Org A was working on a time and materials basis. Org A waived all intellectual property rights to Org B. In contrast, Org B and C have long-term goals beyond the initial product development. Org B wanted to get a product into production cost-effectively and quickly. Org C wanted to create a broad and robust technology know-how that Org C could license or sell to other companies.

☐ NOT WELL-PLANNED COLLABORATIVE PRODUCT DEVELOPMENT PROCESS

The problem occurred because this process was not properly planned. This process was not changed when the process was moved to further from Product Definition phase to Detailed Product Development phase.

☐ NO CLEAR AGREEMENT OF EACH ORGANISATION'S ROLE AND RESPONSIBILITY

This collaborative project had no clear agreement at the beginning: which organisation was the leader in the project and which organisations were in charge of specific tasks in the project. Also, the collaborative team had not set up a clear path of responsibility. There was overlap in the responsibilities. Therefore, the problem occurred because of the ambiguity of each organisation's role in the collaborative project.

☐ NO SUPPORT FROM TOP MANAGEMENT

In this case, Top Management of Org C was not interested in collaboration and negotiation. They wanted more control. Therefore, it caused conflicts and problems during the collaboration. Therefore, Top Management support of each organisation within the collaborative project is important.

To sum up, the main cause of the problems in this collaborative project mainly emerges from: (1) lack of Top Management support, (2) lack of clear agreement of each organisation's role and responsibility, and (3) fixed collaborative design and development process. These caused problems in openness of communication and sharing information.

7.4.9.2 SOUND COLLABORATIVE PRACTICES

☐ JOINT PROBLEM-SOLVING

The collaborative team worked through the problems together by regular meetings.

☐ JOINT DECISION-MAKING

In the early stage, each organisational team made its own decisions. When some decisions were in conflict, group meetings were organised. This case suggests all conflicts could be solved by joint decision-making.

☐ EFFECTIVE COMMUNICATION PROTOCOL

The collaborative team was encouraged to communicate as needed. However, the more disagreements emerged, the less communication became open. It is important that each organisational team leader gets involved when disagreements developed. Disagreement causes problems in communication.

☐ COMMUNICATION ADAPTABILITY

The collaborative team needs to find a common way to communicate because each organisation prefers to communicate in different ways. During the communication, each organisation has to understand the motivations of other collaborative organisations.

7.5 ANALYSIS 2: IDENTIFYING CRITICAL FACTORS

The following sections result from the analysis of the research questions in Part 2.

The critical factors in three main categories are as follows:

7.5.1 WITHIN THE COLLABORATIVE PROCESS

From the analysis of AA's answers (see Table 7-1 in Appendix 7) from the direct, open-ended question: *'In the future collaborative project for the development of*

new products, what will be critical factors which the collaborative team across organisations must concern? And Why?', the factors are:

(1) Clear goals of each organisation involved in the project

(2) Clear communication protocol

7.5.2 WITHIN THE TEAM/ORGANISATION

From the analysis of AA's answers (see Table 7-2 in Appendix 7) from the direct, open-ended question: *'In the future collaborative project for the development of new products, what will be critical factors which your team/organisation must concern? And Why?'*, the factor is:

(1) Efficient abilities of in-house team, such as creating prototypes frequently and maintaining user research as a strong platform

7.5.3 AS THE MAIN POINT OF CONTACT

From the analysis of AA's answers (see Table 7-3 in Appendix 7) from the direct, open-ended question: *'Regarding your role as a main point of contact between your partner and organisation, In the future collaborative project for the development of new products, what will be critical factors which You must concern? And Why?'*, the factors are:

(1) Making clear each organisation's role and responsibility

(2) Making clear a project plan. This case suggests that the project plan should be adjustable during the development process.

7.6 ANALYSIS 3: THE ASSESSMENT OF KEY FACTORS

The following sections result from the analysis of the research questions in Part 3: *'Please identify how critical the following indicators were which underpinned the success of new product collaboration and give me your reasons to support any*

answer.' Please see the research outcome in Table 7-4 in Appendix 7. Regarding the level of mutuality, the research findings of this case study cannot be analysed. This is because there is one organisation participating in this research, instead of all the collaborative organisations. However, the research findings of this section will be observed in the cross-case analysis in Chapter 8.

The outcome of the analysis of all key factors in my hypothesis is shown in Table 7-5 below.

Table 7-5 reveals the analysis of key factors from AA's viewpoint

VALUE	KEY FACTORS
Critical	**Between the main points of contact** ▫ Trust in the abilities between the main points of contact ▫ Mutual respect between the main points of contact ▫ Understanding the distinctive roles of each other between the main points of contact ▫ Equal working relationship between the main points of contact ▫ Effective formal communication between the main points of contact ▫ Open exchange of information between the main points of contact ▫ Ability to communicate well by the main points of contact ▫ Open-mindedness between the main points of contact ▫ Commitment between the main points of contact ▫ Adaptability between the main points of contact ▫ Adjustment of communicative language between the main points of contact **During the collaborative process** ▫ Clear, well-defined collaborative objectives ▫ Mutual benefits of the collaborative project ▫ Mutual understanding the distinctive abilities of the collaborative team across organisations ▫ Joint decision-making concerning this new product ▫ Mutual trust in the abilities of the collaborative team across organisations ▫ Open information exchange of the collaborative team across organisations ▫ Well-planned collaborative design development process ▫ The flexibility of collaborative design development process ▫ Commitment of the collaborative teams across organisations

VALUE	KEY FACTORS(Continued)
Critical	**Within the team/organization** ▫ Innovation culture of your organisation ▫ Innovative abilities of your in-house team ▫ Your team commitment ▫ The flexibility of your team ▫ Top management commitment and support
Important	**Between the main points of contact** ▫ Good interpersonal relationship between the main points of contact ▫ Effective informal communication between the main points of contact ▫ Amicable personality between the main points of contact **During the collaborative process** ▫ Close relationship of the collaborative team across organisations ▫ Joint problem-solving concerning this new product ▫ Effective informal communication within the collaborative team across organisations ▫ Adaptability of the collaborative team across organisations **Within the team/organisation** Your organisation structure

7.7 SUMMARY OF CRITICAL FACTORS

The results of the analyses in Section 7.4 – 7.7 are cross-analysed. Please see the details of the research analysis method in Section 3.8.2. The outcomes of key factors from three Sections are shown in Table 7-6 in Appendix 7. The conclusion is divided into two main parts: (1) critical factors which caused problems during the collaboration, and (2) critical factors which would lead to the project success in the future. The critical factors and their reasons are:

7.7.1 CRITICAL FACTORS CAUSING COLLABORATIVE PROBLEMS

The following factors causing conflicts, disagreements and difficulties during the collaboration are:

1. UNEQUALLY SHARED BENEFITS

All the collaborating organisations must gain. Benefits need to be agreed and/or equally shared. Otherwise, the commitment will not be equal. Agreed benefits strengthen the project commitment among organisations.

2. NOT WELL-PLANNED COLLABORATIVE PRODUCT DEVELOPMENT PROCESS

This process was not well planned in great details at the early stage. Once the project moved from Phase 1 to 2, the process was not changed. AA suggested in Phase 2 that the process should be more formal and well-planned. AA suggested in the future, the collaborative project should have a clear project plan for the whole process.

3. NO CLEAR AGREEMENT OF EACH ORGANISATION'S ROLE AND RESPONSIBILITY

The problem occurs because of the ambiguity of each organisation's role and responsibility within the collaborative network. There was an overlap of expertise between Org A and C. As a result, AA suggested in the future the collaborating organisations should have a clear agreement among their roles and responsibilities.

4. TOP MANAGEMENT SUPPORT

In this case, AA mentioned that the Top Management of Org C was not interested in collaboration and negotiation and wanted more controlled rather than collaborative.

7.7.2 CRITICAL FACTORS WITHIN THE COLLABORATION

The following critical factors that would be needed during the collaborative network are:

- **BETWEEN THE MAIN POINT OF CONTACT**

1. MUTUAL TRUST IN THEIR ABILITIES

Mutual trust in each other's abilities among the main points of contact and within the collaborative teams is critical. Trust affects information sharing. Lack of trust may cause, such as less open information sharing, withholding information, and the modification of information.

2. MUTUAL RESPECT

Mutual respect, among the main points of contact and within the collaborative teams, supports trust and openness.

3. UNDERSTANDING OF DISTINCTIVE ROLES AND RESPONSIBILITIES

Understanding the distinctive roles and responsibilities among the main points of contact and within the collaborative teams is critical. AA suggested that each individual team should contribute what their roles and responsibilities are required. This factor protects the conflicts of overlapping roles and responsibilities which cause collaborative problems.

4. EFFECTIVE COMMUNICATION

Effective communication, particularly formal communication, among the main points of contact is critical. However, this case suggests that effective informal communication is important. Within the collaborative teams, both effective formal and informal communication is also less critical.

5. OPEN INFORMATION SHARING

This factor is critical both among the main points of contact and within the collaborative teams.

6. COMMITMENT

This factor is critical, including among the main points of contact, within the collaborative teams, and each in-house team.

7. ADAPTABILITY

The adaptability among the main points of contact, such as communicative language, is critical. Adapting communicative language helps each partner to listen and learn how to communicate in the language of the other. This strengthens collaboration.

8. EQUAL WORKING RELATIONSHIP

Equality among the main points of contact is critical. In addition, each organisation must be respected because of the project is collaborative. This is the fundamental concept of collaboration. Good interpersonal relationship is also important.

☐ **DURING THE COLLABORATIVE PROCESS**

9. CLEAR, WELL-DEFINED COLLABORATIVE OBJECTIVES AND AGREED GOALS

At the beginning, the collaborative organisations need to have clear objectives and agreed goals. Org A suggested that having clear objectives and agreed goals could make the working system much looser.

10. JOINT DECISION-MAKING

Every collaborative organisation needs to get involved in decision-making.

11. CLEAR, EFFECTIVE COMMUNICATION PROCESS

The collaborative team should have a clear, effective communication process.

12. FLEXIBLE COLLABORATIVE PRODUCT DEVELOPMENT PROCESS

The project has to have a clear project plan at the beginning. Once the project moves along, it has to be able to be adjusted because of the changed project circumstances. AA suggested that in the product definition phase, it should be flexible. In the product development phase, it should be well-defined.

☐ WITHIN THE TEAM/ORGANISATION

13. INNOVATION CULTURE

Innovation culture is the foundation on which all good behaviour is built within an in-house team and organisation.

14. INNOVATIVE ABILITIES OF IN-HOUSE TEAM

15. TOP MANAGEMENT COMMITMENT AND SUPPORT

7.8 REFLECTIONS AND COMMENTS

This project was a short-term, cross-expertise, collaborative network. It started with supply-demand relations. All critical factors of Case Study 4 have been summed up from the design consultancy's viewpoint, instead of all the collaborative organisations because of the problems, conflicts and disagreements during the collaboration. Though the AA's reflection may have bias because of AA's unpleasant experience, my study assumes that the research tool was designed to reduce this bias and reflect needed critical factors. This case study illustrates the contrasting view from the previous three case studies. It reflects critical factors which cause both serious problems and bad experiences, and which are vital during the collaboration. Fortunately, these problems did not lead to a collaborative network failure, and the innovative product was achieved in the end. In this case, the problems originated from three core issues: 'trusting, respecting and understanding each party's distinctive role and responsibility'.

The level of mutuality can not be measured up in this case study regarding the limitation of accessing required information. However, I surmise that, from the AA's reflection, mutuality is still a value-added element which needs to be embedded in most of the critical factors. Particularly, the concept of mutuality in the type of togetherness (see meaning in Glossary) and equality among all the collaborative organisations is critical. This case suggests that lack of both types, especially among the main points of contact, causes problems and conflicts.

There are other assumptions which are revealed from the previous three case studies: the attitude, behavioural and communication aspects, the role of the main point of contact and the compatibility of organisation mindsets. First, from AA's point of view, it is suggested that the attitude and behavioural aspects of the collaborative organisations, such as mutual trust, respect and understanding, and

Top Management support are very important. Lack of these two aspects could cause communication problems and working difficulties among the collaborating participants as this case suggested. Secondly, it is convincing evidence to demonstrate that the role of the main points of contact affects the dynamics of the collaborative network. Regarding all of the answers in Part 3, AA indicated a number of qualitative roles which the main points of contact need to perform as the following: (1) being able to communicate well, (2) being open-minded, (3) being committed, (4) being adjustable, (5) building up trust, (6) being amicable, and (7) understanding others' roles and abilities.

Thirdly, the concept of the compatibility of organisation mindsets cannot be observed from Case Study 4 because there was only evidence from one organisation within the collaborative network.

APPENDIX 7

Table 7-1 reveals the answer of AA who mentioned critical factors which the collaborative team must concern during collaborative product development in the future

INTERVIEWEES	ANSWERS
AA (Org A)	1. "The organisations must have clearly compatible reasons for getting involved – it must be clear that the goals of each organisation are clearly aligned." 2. "A clear communication protocol must be developed"

Table 7-2 reveals the answer of AA who mentioned critical factors which the team/organisation must concern during collaborative product development in the future

INTERVIEWEES	ANSWERS
AA (Org A)	1. "Always create prototypes frequently, to help the team focus on solving particular problems, rather than have discussions based on opinion." 2. "Keep user research as a strong platform for decision-making (a serious staff illness on my team meant that our user research was less comprehensive than it should have been)."

Table 7-3 reveals the answer of AA who mentioned critical factors which the role of the main point of contact must concern during collaborative product development in the future

INTERVIEWEES	ANSWERS
AA (Org A)	1. "Make clear each organisation's roles and responsibilities" 2. "Make a clear project plan that supports a loose product definition phase and then a tight product development phase"

finishing the recent phase, CDP would redefine the working details of the next phase, and put them in a list of the deliver works - based on mutual agreement. As MB reflected on this process: 'usually, we start off with the plan right through to the production. But, the further away from the beginning it is, the more vague it becomes. And then as you work through, you just firm up each section.'

At the end of each phase, as MB mentioned, it is very formal. For example, at the end of Phase One, a list of the delivered works said three prototypes would be delivered and a set of drawings would be on CD. CDP must make sure all the delivered works were there at the end because the finished parts needed to be signed off and RCL needed to pay the bill. Then the next phase would start.

On the other hand, from the client's viewpoint, this process was informal and flexible. It was well-planned at CDP. JR mentioned that RCL did not plan the collaboration. RCL followed CDP's process. As JR mentioned:

"I didn't plan [the collaborative process]. So, the collaboration wasn't planned. They just got on with their work. ... when they needed answers on something, they sent an email or rang up. Then when there were some things that needed a meeting and then I went to see them."

5.4.2.2 PROBLEM-SOLVING DURING THIS PROCESS

Problem-solving during this process depended on issues of design. From the consultant's viewpoint, as mentioned before, the engineering design was all being undertaken in CDP. As a result, the problem-solving was done within the CDP team. As X mentioned:

Table 7-4 reveals the assessment of the key factors which underpinned the successful collaborative network in the development of innovative products

KEY FACTORS	INTERVIEWEE	REASONS
	AA	
Focusing on the main points of contact		
1. Good interpersonal relationship between the main points of contact	3	"It helps to have effective working relationship, but you don't have to be friends."
2. Equal working relationship between the main points of contact	4	"If the project is collaborative, with each party bringing different expertise, then each party must be respected."
3. Trust in the abilities between the main points of contact	5	"Trust is exceptionally important, otherwise information is withheld, modified etc."
4. Effective informal communication between the main points of contact	3	"Formal is more important than informal, but both are important."
5. Effective formal communication between the main points of contact	4	
6. Open exchange of information between the main points of contact	4	"As with the point about trust, above, all communication must be open. Hiding things does not help collaboration."
7. Ability to communicate well by the main points of contact	4	"Each person must be able to make effective use. It is always limited time."
8. Mutual respect between the main points of contact	5	"Trust and openness come from mutual respect."
9. Open-mindedness between the main points of contact	4	"We need to be open-minded, but also to have experience and use our judgement."
10. Amicable personality between the main points of contact	3	"Not as important as respect"
11. Understanding the distinctive roles of each other between the main points of contact	5	"Clear understanding of roles, and respecting others' abilities to fulfil roles"
12. Commitment between the main points of contact	4	Na
13. Adaptability between the main points of contact	4	Na

KEY FACTORS (Continued)	INTERVIEWEE	REASONS
	AA	
14. Adjustment of communicative language between the main points of contact	4	"Each group needs to listen and learn how to communicate in the language of the other."
Focusing on the collaborative process		
15. Clear, well-defined collaborative objectives	5	"With clearly defined and agreed goals, the operational structure can be much looser."
16. Mutual benefits of the collaborative project	5	"Everyone must gain, or else commitment will not be equal."
17. Mutual trust in the abilities of the collaborative team across organisations	4	"It is exceptionally important, otherwise information is withheld, modified etc."
18. Mutual understanding the distinctive abilities of the collaborative team across organizations	5	"If each organisation understands and respects the other, they do not need to know absolutely everything about the other's competencies. They should trust that each organisation will communicate clearly when it has a problem, when it feels out of its depth."
19. Close relationship of the collaborative team across organizations	3	Na
20. Open information exchange of the collaborative team across organisations	4	"Anyone can pick up the phone to speak to anyone else."
21. Well-planned collaborative design development process	4	Na
22. The flexibility of collaborative design development process	4	Na
23. Joint problem-solving concerning this new product	3	"Again, it depends if it's the sort of problem that should be solved jointly. You need to have the correct set of stakeholders - sometimes that is everybody, but sometimes not."
24. Joint decision-making concerning this new product	5	"Not every decision has to be joint, but those that need to be must be."
25. Effective informal communication within the collaborative team across organisations	3	Na
26. Effective formal communication within the collaborative team across organisations	3	Na
27. Commitment of the collaborative teams across organizations	4	Na

KEY FACTORS (Continued)	INTERVIEWEE	REASONS
	AA	
28. Adaptability of the collaborative team across organizations	3	Na
Focusing on in-house team/organisation		
29. Innovative abilities of your in-house team	4	"Not everyone must be innovative, some people need to have roles in the project that are about safe reliable implementation, they must rein in excessive innovation."
30. Your team commitment	4	Na
31. The flexibility of your team	4	"Flexibility is often important for early stages of projects."
32. Innovation culture of your organisation	5	"As with trust and respect, the culture of innovation is the foundation on which all good behaviour is built."
33. Top management commitment and support	4	"Yes, the stakeholders must be supportive."
34. Your organisation structure	3	"As long as the culture is innovative (allowing for experimentation) the structure matters a little less."

Remarks: The value range of each key factor after the analysis: 4-5 = Critical, 3-3.99 = Important, 2-2.99 = Little Important, 1-1.99 = Unimportant

Table 7-6 illustrates the collective research outcomes of key factors from three parts

RESEARCH OUTCOMES OF PART 1	RESEARCH OUTCOMES OF PART 2	RESEARCH OUTCOMES OF PART 3
Causes of collaborative problems ☐ Unequally shared benefits ☐ Fixed collaborative design and development process ☐ No clear agreement of each organisation role and responsibility ☐ No support from Top Management from one of the partner teams **Good practice factors** ☐ Joint problem-solving ☐ Joint decision-making ☐ Effective communication protocol ☐ Communication adaptability within the collaborative team	**As the main point of contact** ☐ To make clear each organisation's roles and responsibilities ☐ To make clear a project plan –loose project plan at the product definition phase and tight plan at the product development phase **Within the collaborative team** ☐ To make clear goals of each organisation to get involved in the project ☐ A clear communication protocol **In your team and organisations** ☐ Efficient abilities of your in-house team –creating prototypes frequently to help team focus on particular problems ☐ Keeping user research as a strong platform for decision-making.	**Between the main point of contact** Critical ☐ Trust in the abilities ☐ Mutual respect ☐ Understanding the distinctive roles ☐ Equal working relationship ☐ Effective formal communication ☐ Open exchange of information ☐ Ability to communicate well ☐ Open-mindedness ☐ Commitment ☐ Adaptability ☐ Adjustment of communicative language Important ☐ Good interpersonal relationship ☐ Effective informal communication ☐ Amicable personality **During the collaborative process/ between collaborative team across organisations** Critical ☐ Clear, well-defined collaborative objectives ☐ Mutual benefits ☐ Mutual understanding the distinctive abilities of the collaborative team ☐ Joint decision-making (To be continued next page)

RESEARCH OUTCOMES OF PART 1	RESEARCH OUTCOMES OF PART 2	RESEARCH OUTCOMES OF PART 3 (Continued)
		Critical (Continued) ☐ Mutual trust in the abilities ☐ Open information exchange ☐ Well-planned collaborative design development process ☐ The flexibility of collaborative design development process ☐ Commitment Important ☐ Close relationship ☐ Joint problem-solving ☐ Effective informal communication ☐ Adaptability **Within your team/organisation** Critical ☐ Innovation culture of your organisation ☐ Innovative abilities of your in-house team ☐ Your team commitment ☐ The flexibility of your team ☐ Top Management commitment and support Important Your organisation structure.

CHAPTER 8: CONCLUSIONS

INTRODUCTION TO CHAPTER 8

Chapters 4 – 7 report the investigation of four network case studies. The underlying critical factors which underpinned success of particular collaborative networks in the development of innovative products in each network case study are identified.

Chapter 8 derives conclusions from the four network case studies by cross-case analysis. It also summarises and reflects the research findings and experience. Chapter 8 consists of the following sections:

Section 8.1 illustrates cross-case analysis of the four research case studies, including (i) the examination of critical factors, (ii) the identification of effects of each critical factor, (iii) the examination of the level of mutuality of each critical factor, (iv) the examination of critical elements within the collaborative network, (v) the examination of the relationship between critical factors and the collaborative network duration, and (vi) the examination of the relationship between critical factors and collaborative organisation roles.

Section 8.2 summarises the entire research.

Section 8.3 describes contributions of my research.

Section 8.4 reflects on some important issues that emerged during the research, including the establishment of collaborative networks, the status quo of the network case study, the characteristics of collaborative organisations, and the research methodology.

8.1 CROSS-CASE ANALYSIS

8.1.1 CRITICAL FACTORS

My research aim was, '*to identify critical factors that contribute to the success of collaborative networks in the development of innovative products, and to define and evaluate helpful aspects of each critical factor*', the results of the critical factors of the four network case studies are cross-analysed, as shown in Table 8-1 and 8-2 in Appendix 8. The analysis is based on the grouping of their similarities. The critical factors are as follows:

1. MUTUAL TRUST

All of the cases confirm that mutual trust of the abilities of the corresponding main points of contact is critical. Case Studies 3 and 4 suggest that mutual trust between the collaborative teams is also critical.

2. GOOD INTERPERSONAL RELATIONSHIP

Case Studies 1, 2 and 3 suggest the importance of a good interpersonal relationship between the main points of contact. However, Case study 4 indicates that it is not critical to success.

3. EQUAL VALUING OF WORING ROLES

All of the cases confirm that a non-hierarchical working relationship between/among the collaborative teams is critical. Case Studies 1 and 2 suggest that a colleague-like relationship is advisable to facilitate the motivation of the collaborative teams.

4. MUTUAL RESPECT

Case Study 4 indicates that lack of mutual respect among the main points of contact and the collaborative teams can cause serious conflicts during collaboration. Case Studies 1 and 2 also touch on this factor.

5. CLEAR AGREEMENT ON THE COLLABORATIVE BENEFITS

All of the cases confirm that a shared agreement of perspective about the value of the benefits of collaboration in the collaborating organisations is critical. Case Studies 1 and 4 suggest that benefits of collaboration should be equally shared. Case Studies 1, 2 and 3 suggest that an agreement on the benefits of collaboration should be clearly stated in the legal contract after the negotiation between the organisations before the collaborative project is started. Intellectual property rights are in everyone's interest to clarify.

6. AN EFFECTIVE COMMUNICATION PROTOCOL

All of the cases confirm that having an effective communication protocol for both formal and informal communication is critical, particularly between/among the main points of contact. Case Studies 1, 2 and 3 suggest that an effective informal communication protocol is very important to a successful collaborative network for design innovation.

7. FLEXIBLE COLLABORATIVE PRODUCT DEVELOPMENT PROCESS

All of the cases confirm that flexibility during the collaborative product development phase is critical. Four cases suggest that each phase during this process needs to be scheduled to match the nature of innovative product development which is inherently uncertain and unpredictable.

8. CLEAR, WELL-DEFINED COLLABORATIVE OBJECTIVES AND GOALS

Case Studies 1, 2 and 4 suggest the importance of clear, well-defined collaborative objectives and goals. Case Study 3 shows that they are less critical to success.

9. OPEN INFORMATION SHARING

All of the cases confirm that open sharing of the information, especially between/among the main points of contact, is critical. Case Studies 1 and 4 suggest that when an in-house team from each organisation gets involved, open information sharing is especially important.

10. COLLABORATIVE ATTITUDE (MINDSET)

All of the cases confirm that a 'collaborative attitude', i.e. a mutual understanding between the parties, is critical. Case Studies 1, 3 and 4 suggest that a mutual understanding on the distinctive roles, abilities, skills, and responsibilities among the main points of contact is very important. Case Studies 2 and 3 also suggest that a mutual understanding of each other's requirements, constraints, difficulties, viewpoints, intentions, drives, and expectations is highly important.

11. COMMITMENT

All of the cases confirm that commitment at every level during the collaborative networking process is critical, including between/among the main points of contact, the collaborative team, the in-house team of each organisation, and the Top Management of each organisation.

12. ADAPTABILITY

Case Studies 2, 3 and 4 suggest the importance of adaptability, especially between the main points of contact.

13. JOINT PROBLEM-SOLVING

All of the cases confirm that it is not necessary to jointly solve every problem during the collaborative product development process. However, Case Studies 1, 2 and 3 suggest that joint problem-solving is critical when addressing significant product development issues. Additionally, Case Study 4 suggests the importance of having the right stakeholders involved in each problem solving process.

14. JOINT DECISION-MAKING

Case Studies 2, 3 and 4 suggest that joint decision-making is critical, especially on significant issues. However, all of the cases agree that the final decision of design innovation in any collaborative project is determined by the collaborative network initiator.

15. INNOVATIVE ABILITIES OF EACH IN-HOUSE TEAM

Case Studies 1, 3 and 4 suggest that the innovative abilities of each of the in-house team play a significant role. Case Study 2 also suggests that teams should have the ability to work efficiently.

16. INNOVATION CULTURE OF EACH ORGANISATION

All of the cases confirm that the existence of organisational cultures which are conducive and supportive of innovation is critical in the collaborating organisations.

To sum up, the four case studies suggest sixteen critical factors that the collaborative organisations need to be concerned with. Table 8-2.1 shows a summary of the subsequent research findings of critical factors in comparison with the initial hypothesis.

Table 8-2.1 summarises sixteen critical factors of subsequent research findings in comparison with ten key factors in the original hypothesis

OBSERVED FACTORS	CRITICAL FACTORS	
	INITIAL HYPOTHESIS	SUBSEQUENT RESEARCH FINDINGS
Adaptability	Adaptability between organisations might be a critical factor.	The study shows adaptability between the main points of contact
Commitment	Commitment to the collaborative product development might be a critical factor.	The study shows commitment at all levels, including the main point of contact, the collaborative team and Top Management of each organisation
Communication	Effective communication might be a critical factor.	Effective communication protocol, especially informal communication protocol between the main points of contact
Well-organised product development process	Well-planned collaborative product development process might be a critical factor.	The study shows flexible collaborative product development process
Reciprocity	Open information exchange might be a critical factor.	The study shows (i) open information sharing between the main points of contact and the collaborative team, and (ii) clear agreement of collaborative benefits
Relationship	Good personal relationship might be a critical factor.	The study shows (i) good interpersonal relationship between the main points of contact, and (ii) equal valuing of working roles between the collaborative teams, especially colleague-like relationship
Self-regeneration	An autonomous ability of each organisation to innovate might be a critical factor.	The study shows (i) innovative abilities of in-house team, and (ii) innovation culture within each organization
Shared empowerment	(i) Joint problem-solving might be a critical factor. (ii) Joint decision-making might be a critical factor.	The study shows (i) joint problem-solving on significant issues, and (ii) joint decision-making on significant issues
Trust	Trust in the abilities of the collaborative organisations might be a critical factor.	The study shows mutual trust in the abilities between the main points of contact and the collaborative team
FACTORS EMERGING FROM THE CASE STUDIES		
Respect		There needs to be mutual Respect between the main points of contact and the collaborative team

OBSERVED FACTORS (Continued)	CRITICAL FACTORS	
	INITIAL HYPOTHESIS	SUBSEQUENT RESEARCH FINDINGS
'Collaborative attitude'		There needs to be (i) mutual understanding on the distinctive roles, abilities, skills and responsibilities between the main points of contact, and (ii) understanding of each other's requirements, constraints, difficulties, viewpoints, intentions, drives and expectations
Determinate objective		There needs to be clear, well-defined collaborative objectives and goals

As shown in Table 8-2.1 above, the research findings suggest more critical factors that need to be highlighted:

(1) Focusing on the issue of reciprocity, a clear agreement about the collaborative benefits needs to be taken into account in addition to open information sharing.

(2) In the product development process, a well-planned collaborative product development process is not necessarily optimal. The product development process needs to be flexible in each phase during the collaborative product development process.

(3) Focusing on the issue of relationship, in addition to a good interpersonal relationship, a non-hierarchical working relationship is also important.

(4) Focusing on the issue of adaptability, adaptability at the personal level is more critical than adaptability at the organisational level. The findings suggest that the main points of contact during the collaboration need to be adaptable.

(5) Three critical factors need to be added in: (i) clear, well-defined collaborative objectives and goals, (ii) collaborative attitude of the collaborative teams, and (iii) mutual respect.

Out of sixteen critical factors, according to the research findings, my study suggests that nine critical factors emerge to be dominant for the success of collaborative networks: (1) Mutual trust, (2) Equal valuing of working role, (3) Clear agreement of the collaborative benefits, (4) An effective communication protocol, (5) Flexible collaborative product development, (6) Open information sharing, (7) Mutual understanding between the parties, (8) Commitment at all levels, and (9) Innovation culture of each organisation.

8.1.2 EFFECTS OF THE CRITICAL FACTORS

The sixteen critical factors were identified. My next research aim was, *which is to generalise the effects of each critical factor*, the effects of each critical factor from the research findings of the four case studies are cross-analysed. The analysis is based on all replies collected from the research participants, as shown in Table 8-3 to 8-18 in Appendix 8. The relative effects of each critical factor that strengthens the success of a collaborative network are shown in Table 8-18.1.

Table 8-18.1 summarises the relative effects of each critical factor

CRITICAL FACTORS	EFFECTS ON THE SUCCESS OF COLLABORATION
1. Mutual trust	(i) Strengthening working relationship at a personal level and building mutual trust at an organisation level (ii) Engendering self-confidence of the collaborative project (iii) Having a positive effect on open communication and information sharing
2. Good interpersonal relationship	(i) Supporting open communication and information sharing (ii) Building up trust and respect (iii) Promoting long-term collaboration (iv) Supporting ease of working (v) Enhancing productive collaboration and the quality of the design solution
3. Equal valuing of working roles	(i) Supporting motivation (ii) Encouraging learning (iii) Relating to respect (Continued)

CRITICAL FACTORS (Continued)	EFFECTS ON THE SUCCESS OF COLLABORATION
4. Mutual respect	(i) Building up working relationships (ii) Decreasing working problems and conflicts (iii) Supporting trust and openness
5. Clear agreement on the collaborative benefits	(i) Preventing working problems if the project fails (ii) Strengthening commitment
6. Effective communication protocol	(i) Resulting in time-savings and working more effectively and efficiently (iii) Improving project monitoring (iv) Facilitating open communication and discussion
7. Flexible collaborative product development process	(i) Sustaining long-term project collaboration (ii) Encouraging creativity (iii) Increasing the value of the end product
8. Clear, well-defined collaborative objectives and goals	Positively affecting the working relationship, budget spending and working system
9. Open information sharing	(i) Increasing trust (ii) Reducing problems and failures (iii) Sustaining joint activities
10. Collaborative attitude	Facilitating and optimizing effective collaboration as a whole
11. Commitment within the collaborative teams	(i) Empowering and sustaining the whole collaborative network (ii) Supporting the development of long-term relationships (iii) Facilitating the project progress (iv) Contributing to the production of better innovative products
11.1 Top Management's commitment within each organisation	(i) Encouraging external collaboration (ii) Motivating and giving confidence to the in-house teams
12. Adaptability	(i) Strengthening effective collaboration (ii) Supporting willingness within the collaborative teams to adjust to change
13. Joint problem-solving	(i) Increasing motivation (ii) Supporting the initiation of new ideas and the creation of the best design solution (iii) Helping to save time and money (iv) Avoiding the possibility of problems getting worse
14. Joint decision-making	(i) Helping to save time and money (ii) Avoiding the risk of generating infeasible designs or exceeding cost constraints
15. Innovative abilities of each in-house team	Helping to strengthen an innovation culture of the organisations
16. Innovation culture of each organisation	(i) Being a foundation on which all value behaviour is built within the in-house team and organisation (ii) Providing the in-house team with support and encouragement (iii) Stimulating the excitement and confidence of the partner organization

In addition, my study analyses all of the effects of the critical factors. Instead of knowing each critical factor and its effects as mentioned above, my study synthesises all of the consequential effects of the critical factors to understand which set of critical factors are most responsible for any particular desired outcome. The analysis aims to understand the relationships between solutions and critical factors. It intends to generate, what I call 'solution-based guidelines' to use in improving the effectiveness of collaborative, multidisciplinary networks. In comparison with general recommendations from previous studies in the areas of innovation strategy (e.g. Hamel and Prahalad, 1994; Utterback, 1994) and design strategy (e.g. Jevnaker, 1998; Bruce and Jevnaker, 1998), my solution-based guidelines are slightly different from them. The general recommendations of the previous studies tend to introduce, what I call 'scenarios-based guidelines'.

The scenarios-based guidelines tend to lead organisations to think and/or act differently, based on the scenarios of future circumstances. Firms tend to be recommended on how to behave in particular ways in order to get better performance for particular activities, or to act differently from their normal, expected strategies, norms or practices.

Instead, my solution-based guidelines suggest the required approach which organisations are recommended to take action in particular potential circumstances in order to avoid or prevent hidden, predictable problems, or to get a potentially desired result. My guidelines are also introduced in a more innovative way in comparison with the previous studies' recommendations. They suggest not only the required approaches, but also their interrelations, which are likely to support firms to analyse their behaviour, to understand a holistic view of the interrelated critical factors, and to strategically use them both directly and indirectly.

With my solution-based guidelines, the collaborating organisations can prevent problems and conflicts, more accurately predict desired outcomes, and/or more effectively cultivate and/or reinforce the collaborative design processes of innovative products. The connections among all of the effects of the critical factors are built up, based on the analysis methods of data visualisation and graph theory (see Section 3.8.3). The analysis is shown in Diagrams 8-1 and 8-2 in Appendix 8. It suggests two main findings: (i) relationships between critical factors and their effects and (ii) relationships between the critical factors themselves.

8.1.2.1 MAPPING THE RELATIONSHIPS BETWEEN CRITICAL FACTORS AND THEIR EFFECTS

Table 8-18.2 below shows my recommendations, based on the data as shown in Diagram 8-1, which are the solution-based guidelines which the collaborative organisations should implement during a collaborative network.

8.1.2.2 MAPPING THE RELATIONSHIPS BETWEEN THE CRITICAL FACTORS

As shown in Diagram 8.2, the findings suggest that there are two pairs of bilateral relationships: (i) mutual trust and open-communication, and (ii) mutual respect and working relationships. This means without mutual trust, the collaborative organisations would be very difficult to have open communication (open information sharing and/or discussions) during the collaboration and vice versa. Without mutual respect, the collaborative organisations would be very difficult to build up equal working relationships during the collaboration and vice versa. Diagram 8.2 also suggests that if the collaborative organisations have not well established mutual trust, open communication, good interpersonal

relationship, and equal valuing of working roles would have been difficult to be built up within a collaborative network.

Table 8-18.2 summarises relationships between a set of critical factors and their desired outcomes

OUTCOMES	CONTRIBUTORY FACTORS
▪ To reduce or prevent working problems and conflicts	(i) Agreed benefits, (ii) Mutual respect (iii) Openness of communication, information sharing and discussion
▪ To boost the quality of design solution and innovative product values	(i) Commitment at all levels (ii) Good interpersonal relationship (iii) Joint problem-solving (iv) Flexible collaborative product development process
▪ To sustain long-term collaboration	(i) Commitment at all levels (ii) Good interpersonal relationship (iii) Flexible collaborative product development
▪ To empower effective, efficient and productive collaboration	(i) Commitment at all levels (ii) Good interpersonal relationship (iii) Collaborative attitude (iv) Effective communication protocol
▪ To build up confidence between the collaborative organisations	(i) Innovation culture of each organisation (ii) Mutual trust (iii) The commitment of the Top management of each organization
▪ To save times and costs during the collaboration	(i) Agreement of collaborative objectives and goals (ii) Effective communication protocol (iii) Joint problem-solving (iv) Joint decision-making
▪ To support motivation within the collaborative team	(i) Equal valuing of working roles (ii) Joint problem-solving
▪ To build up trust within the collaborative network	(i) Mutual respect (ii) Good interpersonal relationship (iii) Open communication
▪ To generate open communication, discussion and information sharing	(i) Effective communication protocol (ii) Mutual trust (iii) Mutual respect (iv) Good interpersonal relationship
▪ To build up good, equal working relationship between the collaborative organisations	(i) Commitment at all levels (ii) Agreement of collaborative objectives and goals (iii) Mutual trust (iv) Mutual respect

8.1.3 LEVEL OF MUTUALITY

My research aim was, *to examine the level of mutuality of each critical factor within the collaborative organisations*, the research findings of the four network case studies are cross-analysed (see the detail of the analysis method in Section 3.8.4). Please note, this analysis method was appropriately used in Case Studies 1 and 2. In Case Studies 3 and 4, this method has not been used because the research information was less satisfactory as a result of a missing of collaborating parts. However, my study understood the circumstances of Case Studies 3 and 4 before the investigation of both case studies was started. Therefore, all key factor wordings are slightly adjusted (as demonstrated in Section 3.7.3). These wording adjustments aim to reflect the significance of the level of mutuality of each key factor between the collaborative organisations within collaborative networks.

My study hypothesises that, to work successfully within collaborative networks of multidisciplinary organisations in the development of innovative products, each critical factor should have a high level of mutuality between collaborating organisations. To answer this proposition, I decided to use the research findings of all four case studies, instead of just the results of Case Studies 1 and 2. This is because Case Studies 3 and 4 can reflect the level of mutuality between/among the collaborative organisations through the data collection tool in Part 3 of Questionnaire 4. They also help to strengthen the research result. Regarding the analysis of the four case studies as shown in Table 8-18.3 in Appendix 8, the findings suggest the level of mutuality of each critical factor as shown in Table 8-18.4.

Table 8-18.4 summarises the research findings of the level of mutuality of each critical factor

FACTORS	CRITICAL FACTORS	LEVEL OF MUTUALITY
Adaptability	Adaptability between organisations	Medium
Commitment	Commitment to the collaborative product development	High
Communication	Effective communication protocols	High
Well-organised process	Well-planned collaborative product development process	Medium
	Flexible collaborative product development process	Medium
Reciprocity	Open information sharing	High
	Clear agreement on the collaborative benefits	High
Relationship	Good interpersonal relationships	High
	Equal valuing of working roles	High
Self-regeneration	Innovative abilities of in-house team	Medium
	Innovation culture of each collaborative organisation	High
Shared empowerment	Joint problem-solving	Medium
	Joint decision-making	Medium
Trust	Mutual trust in the abilities of the collaborative organisations	High
Respect	Mutual respect	High
Collaborative attitude	Understanding each other's distinctive roles and abilities	High
Determinate objective	Clear, well-defined collaborative objectives and goals	High

As shown in Table 8-18.4, the findings suggest that a majority of the critical factors contain high level of mutuality between/among the collaborating organisations. The findings also suggest that some critical factors are unlikely to have a high level of mutuality as, for example, in joint problem-solving, joint decision-making, adaptability between the collaborative organisations; they tend to have a medium level of mutuality. Moreover, the research findings suggest that the level of mutuality in each critical factor is dependent on different, particular conditions in each case.

On further analysis, based on the data, the findings also suggest that mutuality possesses the following contextual characteristics:

(1) **The examples of equality that contributes to mutuality**. The collaborating organisations should treat each other as equals. In effect, I found the presence of the equality in the following critical factors: working relationship and mutual respect.

(2) **The examples of reciprocity that contributes to mutuality**. Reciprocity refers to the activity of exchange which does not need to act simultaneously. The collaborating organisations should reciprocally exchange. In effect, I found the presence of reciprocity in the following critical factors: information sharing and open communication protocol.

(3) **The examples of similarity that contributes to mutuality**. The collaborating organisations should have similar characteristics. In effect, I found the presence of the similarity in the following critical factors: innovation culture of each organisation, understanding each other's distinctive roles and abilities, commitment, respect, and trust.

(4) **The examples of agreement that contributes to mutuality**. The collaborating organisations should have mutual agreement on the following critical factors: determinate objective and agreed benefits of collaborative networks.

(5) **The examples of togetherness that contributes to mutuality**. Togetherness refers to the action which the collaborative team needs to act together simultaneously and/or cooperatively in order to reach a resolution. Togetherness between the collaborative organisations is essential when dealing with some significant issues related to innovative products. In effect, I found the presence of togetherness in the following critical factors: problem-solving and decision-making.

To sum up, all critical factors within the success of collaborative networks in the development of innovative products tend to have a high level of mutuality

between/among the collaborative organisations. The concept of mutuality consists of five main contextual characteristics: equality, reciprocity, similarity, agreement, and togetherness. My study believes that these five characteristics are the significant components of mutuality. They strengthen one another and emerge as the concept of mutuality. Mutuality is an emergent property of a sum of the five characteristics. The findings also suggest that, as shown in Case Studies 1, 2, and 3, the collaborative organisations which uphold high level of mutuality in the five contextual characteristics within collaborative networks tend to have less working problems and conflicts. In addition, the collaborative organisations which uphold low levels of mutuality in the five contextual characteristics tend to have more working problems and conflicts within collaborative networks, as shown in Case Study 4.

8.1.4 CRITICAL ELEMENTS WITHIN COLLABORATIVE NETWORKS

Section 8.1.1 to 8.1.3 shows how four main research aims were satisfactorily addressed. Section 8.1.4 analyses critical elements within collaborative networks. Based on the network analysis method, 'dyad analysis' (see Section 3.8.3), the findings suggest four key elements which tend to strengthen a successful relationship between/among the collaborating organisations: (i) a main point of contact, (ii) the collaborative process, (iii) each individual team/organisation, and (iv) relational links. The critical factors in each element are identified as follows:

8.1.4.1 A MAIN POINT OF CONTACT

In Table 8-19 and 8-20 in Appendix 8, the key attributes of a main point of contact within collaborative networks, which underpin the success in the development of innovative products are as follows:

(1) The ability to develop personal relationships with others who are the main points of contact

(2) The ability to adapt communicative language to other main points of contact

(3) The ability to communicate well, openly and honestly

(4) Having collaborative spirits –the ability to understand, respect and trust others' distinctive roles and knowledge, and being open-minded

(5) Being an efficient mediator between external and internal team

(6) Having commitment to the collaborative project

8.1.4.2 DURING THE COLLABORATIVE PROCESS

During the collaborative process, the collaborating organisations should act upon the following critical factors: (1) an effective communication protocol, (2) a flexible collaborative product development process, (3) clear, well-defined collaborative objectives and goals, (4) open information sharing, (5) commitment, and (6) mutual trust.

8.1.4.3 EACH INDIVIDUAL TEAM/ORGANISATION

Within collaborative networks, each individual team/organisation should have the following: (1) innovative abilities of each in-house team, (2) innovation culture of each organisation, and (3) Top Management commitment and support. Regarding the second factor, my study uncovered further details by analysing relevant evidence on the research findings. It concludes that the innovative culture of each individual organisation would require:

(1) That the organisation structure is flexible and non-hierarchical

(2) That the organisation values open, informal communication, connections and interactions within its boundary

(3) That the organisation values connection and interaction with other external organisations

8.1.4.4 RELATIONAL LINKS

In dyadic research, they deal with the relational links. In this case, this corresponds to working relationships, and I will use the term, working relationships. In Table 8-21 in Appendix 8, Case Studies 1, 2 and 3 highlight which working relationships support a successful collaborative network. Case Study 4 highlights the working relationships which lead to working difficulties and conflicts within the network. The findings suggest the interwoven set of key working relationships between/among collaborative organisations which lead to the success of collaborative networks in the development of innovative products as follows: (1) complementary interest, (2) agreed mutually benefits, (3) personal relationship, (4) complementary skills and knowledge, (5) effective communication protocol, and (6) collaborative attitude –trusting, respecting and understanding each other.

8.1.5 CRITICAL FACTORS INFLUENCING THE NETWORK'S LIFETIME

Section 8.1.5 analyses how differences in the collaborative network's lifetime affect the critical factors. The research findings of Case Studies 1, 2 and 3 are analysed. The comparison between critical factors of the three case studies which have the different durations and the research findings of the sixteen critical factors of all case studies is shown in Table 8-22 in Appendix 8. The evidence did not show that the different durations of the three case studies had a significant effect on variables of the critical factors. This means that, for practical purposes, either short-term or long-term collaborative networks, the critical factors for the success of collaborative networks in the development of innovative products are comparatively similar. As a consequence, my study suggests that all critical factors, as mentioned in Section 8.1.1, are likely to be used as guidelines for both short-term and long-term collaborative networks.

Nevertheless, the in-depth analysis of the critical factors of three case studies, as shown in Table 8-1 in Appendix 8, suggests that the characteristics of the collaborative partner in the long-term collaborative network (Case Study 1) in comparison with the short-term collaborative networks (Case Studies 2 and 3) is distinctive. The long-term collaborative partner has not only the right capabilities, but also the right mindsets. I would surmise that to sustain long-term collaboration, both right capabilities and mindsets should be taken into consideration when working with or selecting the collaborative partner.

8.1.6 CRITICAL FACTORS AND COLLABORATIVE ORGANISATION ROLES

Section 8.1.6 analyses the relationship between roles of collaborative organisations and variables of critical factors. Based on my observation of the four case studies, the collaborative organisations were divided into two roles: (1) network initiator and (2) network collaborator. A network initiator is an organisation which decides to build up a collaborative network. A network collaborator is an organisation which is selected and decides to join the collaborative network. Table 8-23 in Appendix 8 illustrates two roles of the collaborative organisations in the four network case studies. Table 8-23 suggests that BAE and RCL are the network initiators. NOT, CDP, a technology organisation (Case Study 3), and a design consultancy (Case Study 4) are the network collaborators.

The analyses of the relationship between the roles of the collaborative organisations and the variables of their identified critical factors are shown in Table 8-24 and 8-26 in Appendix 8. My analysis of Table 8-24 suggests that the two network initiators contain some similar roles within collaborative networks as follows: (i) they understand the partners' viewpoints and the partners' nature of works and skills, and (ii) they define clear collaborative goal and agreement. In

addition, they have the following in-house qualities: efficient abilities of in-house team, and Top Management commitment and support. Moreover, within the successful collaborative networks, the network initiators do not perform their roles as the network leaders, but they tend to be the network facilitators and mediators. My analysis of Table 8-25 suggests that the roles of the four network collaborators are diverse. Their roles depend on collaborative circumstances and conditions. In all cases, the data indicates that the network initiators had been given to make a final decision in the project.

8.2 CONCLUSION

This data has so far supported my research question in the importance of organisations establishing networks of innovation to create or guide the development of innovative products.

Chapter 1 suggests that the routine creation of innovative products is now almost standard practice as a survival strategy for any organisation in the global, post-industrial economy. It identifies the difficulty of continuing to develop innovative products, including the limitations of their in-house experience and resources, the intrinsic problems of innovative product development (high risk, uncertainties and fixed, soaring cost), and unpredictable and complex conditions surrounding innovative products. It suggests that the external complex conditions would also provide positive opportunities. My personal view, based on my cultural and religion background and professional experience of designing good innovative products, is included so as to support my standing point and suggest the best way forwards. As a consequence, my study indicates that, not only do good innovative products have to be continuously designed/created/developed, but also that an effective design network needs to be in place. My study suggests that organisations should network with each other.

Chapter 2 defines the concept of networks. A network is defined as a system of interacting parts and their relations. My study indicates that a coherent set of relations among interacting parts is an essential part within the concept of a network. Chapter 2 reports the existing perspectives relating to organisation networks and the existing models of organisation networks relating to the development of innovative products. It analyses the benefits of organisation networks towards an entire network, networking organisations and product innovation. The analysis suggests that organisation networks introduce certain

positive values that promote innovation and flexibility. These help organisations to be able to sustain themselves in complex and unpredictable conditions. Organisation networks help the activity of product innovation to increase flexibility. By doing so, they also can access resources at both a tacit knowledge and an explicit knowledge of other organisations because of the adaptability of their structure. Moreover, they enhance innovation ability to continually generate new products in response to rapidly changing demands of the commercial market because they provide a number of benefits in product development, such as risk sharing, cost reduction and shorter lead time to market.

Based on the existing models of organisation networks related to product development, organisation networks are divided into three types: centre-focused networks, hierarchical networks and collaborative, decentralised networks. My study reflects upon these three types by comparing them with the philosophical nature of the network system. It asks whether, for example, it is more closed or open; a mechanical or an organic system. Some studies in biology (Capra, 2002) and complex theory (Waldrop, 1992) suggest that 'living', 'complex', or 'self-organising' network systems are able to be open, responsive and adaptive to changing environment. They also possess creative potentials; abilities to learn and innovate. Based on these arguments and the views of theorists and design professionals, my study shows how collaborative networks of multidisciplinary organisations are an appropriate network feature in the development of innovative products. Chapter 2 argues that the qualities of the networking system tend to benefit individuals, individual businesses and the whole economy for creativity, innovation and flexibility. It summarises that a coherent set of relations among collaborating organisations is the critical aspect, which need to be further investigated in order to enable the success of working relationships among collaborative organisations in the development of innovative products.

Chapter 3 states my research methodology. Four successful network case studies are selected from two pilot studies within the UK. The visibility of innovative products in the market is an indicator to measure the success of network. Because of the limited circumstances surrounding these case studies: sensitive issues of innovative product development and the difficult accessibility of the network case studies, my study decides to use the research method of theory testing to examine all cases. Reviewing the empirical and theoretical studies of organisation networks, network systems and the management of product development, ten key factors and one hypothesis are identified as guidelines for the research investigation. The corresponding main points of contact between the collaborating organisations which interacted and worked closely during collaborative networks are mainly face-to-face interviews. Some research participants are investigated by a questionnaire because they refused to participate in interviews and were very busy with their routine work. Four network case studies are investigated in sequence:

(1) Case study 1, reported in Chapter 4, the collaborative network between BAE (a manufacturing-based organisation) and NOT (a technological knowledge-based organisation) in the development of radical design-oriented applications of a Silicon Gyroscope.

(2) Case Study 2, reported in Chapter 5, the collaborative network between RCL (a marketing-based organisation) and CDP (a design consultancy) in the development of the remote controlled light.

(3) Case Study 3, reported in Chapter 6, the collaborative network between a small technology-based organisation and a manufacturing-based organisation in the development of innovative Product YY.

(4) Case Study 4, reported in Chapter 7, the collaborative network among a technology-based organisation, a design consultancy and a manufacturing-based organisation in the development of an innovative product.

There are some limitations in the data collections of Case Studies 3 and 4. This is because the sensitive issues surround the nature of the collaborative product development network: the issue of a legal contract of product confidentiality (in Case Study 3) and the issue of business relationships among organisations in the future (in Case Study 4). Therefore, the research outcomes of Case Studies 3 and 4 are reflected from one organisation view, rather than the whole collaborative organisations. Each case study suggests critical factors which contribute to the success of collaborative networks.

The final chapter addresses four main research aims with a cross-case analysis of all of the case studies. First, Section 8.1.1 indicates sixteen critical factors, working concurrently, should support the success of collaborative networks of multidisciplinary organisations in the development of innovative products. My study suggests that nine out of sixteen critical factors emerge to be dominant. Secondly, Section 8.1.2 suggests the effects of each critical factor which contribute to the success of collaborative networks. It also recommends the solution-based guidelines that would help the collaborative organisations to work together effectively. Thirdly, Section 8.1.3 indicates that a majority of critical factors within the success of collaborative networks tend to contain a high level of mutuality. It also suggests that the level of mutuality in each critical factor is dependent on different, particular conditions in each case. Five key characteristics are the components of the concept of mutuality that the collaborative organisations should act upon to reduce working problems and conflicts during collaboration: equality, reciprocity, similarity, agreement, and togetherness. Moreover, it suggests that the collaborative organisations which uphold high level

of mutuality in the five contextual characteristics within collaborative networks tend to have less working problems and conflicts. Fourthly, Section 8.1.4 categorises all research findings of the case studies, by using the dyad network analysis method. It suggests four key elements as interdependent entities which would strengthen the success of collaborative networks: a main point of contact, the collaborative process, each individual team/organisation, and working relationships between collaborative organisations. Fifthly, Section 8.1.5 suggests that the identified sixteen critical factors can be used as practical guidelines for either short-term or long-term collaboration. Finally, Section 8.1.6 suggests that the role of network initiators is essential to collaboration success. It indicates that network initiators should not perform their role as the network leader or controller, but tend to be the network facilitator and mediator.

According to the research findings regarding the critical factors, the success of collaborative product development networks between/among multidisciplinary organisations is based on attitude, behavioural and communication aspects of each organisation and as a team. First, the collaborative success requires a new set of organisational attitudes. There is no longer an arbitrary control over rank. Instead, organisations acknowledge the value of equals, associates, respect and trust. This point confirms the proposition of Drucker (1998) in managing the relationships between different organisations in what he called the new Network Society. Secondly, regarding behavioural aspects, the collaborative team requires behaving and working together as a team, rather than a mechanistic entity. Each organisation adapts to the character, the capabilities, the strengths and the weaknesses of other team partners along the dynamics of product development process. Simultaneously, the whole team voluntarily commits to move together while collaborating organisation partners retain their interrelating positions, though each organisation has a particular interest and fixed responsibility. Problem-solving and decision-making processes tend to be joint action,

particularly in the significant issues. Also, each organisation requires an innovation culture that creates a supportive environment for people to act cooperatively and creatively. Previous studies (Kanter, 1983; Mullins, 2002; Buchanan et al, 2004) suggest that an environment that encourages innovation is important for organisational behaviour and dynamics, my study suggests that it is also significant for supporting the collaborative network. Finally, communication strategies in the collaborative teams are based on sharing information reciprocally and openly, and effective communication protocol, in particular informally. This point confirms the significance of the dynamics of communicating and information sharing in social interaction in generating creative, unanticipated outcomes, referred by Stacey (1996, 2003).

The previous studies in organisational dynamics (Stacey, 1996; 2003) and organisational behaviour (Kanter, 1983; Mullins, 2002) suggest that people are valuable assets of organisations. They argue that continuous innovation is based on the dynamics of human interactions. In the collaborative product development network, my research findings support this point: its success is strongly based on 'person-to-person' interactions. Though my research has not been investigated in depth on the collaborative participants' knowledge embedded in individual experience and involving such intangible factors as personal belief, perspective, instinct and values, the personal attributes, generally speaking, of the main points of contact as suggested in Section 8.1.4.1, become a crucial aspect during collaboration. Case Studies 1 and 2 suggest that 'disliking a person' or being incompatible on a personal level between/among the main points of contact would lead to a disconnection between the collaborating organisations. The findings further suggest that the collaborative success emerges from, not only the individual attributes, but also complex interactions of different relationships, such as person-to-person relationship, communication, complementary interest, skills and knowledge, trust, respect, and mutual understanding.

As mentioned in Section 3.2, two previous works of Bruce et al (1995) and Sale and Wilkinson (1999) have similarities to mine. By comparing my research findings (as mentioned in Section 8.1.1) with the findings of both studies, according to the difference in the research rationale and methodology, it is interesting to see that many variables of key factors are relatively similar:

Regarding the findings of Bruce et al, the following key factors are relatively similar to mine: a climate of trust, personal relationships, perception of equality in contributions and benefits, commitment at all levels, Top Management commitment, mutual understanding, flexibility by all parties, clearly defined objectives and responsibilities, and frequent communication. Concerning the suggestion of Sale and Wilkinson, the following significant issues are relevant to my findings: willingness to commit to work cooperatively, open lines of communication, ensuring responsiveness and flexibility of partnership team when changes happen, reciprocity (sharing information, ideas, costs and resources), mutual benefits, equal relationships, ensuring regular meetings and project reviews, assimilating cultural and management differences, clearly defined all roles, and identifying the project focus.

To sum up, both previous studies address, broadly speaking, these key factors: commitment, communication, flexibility, reciprocity (sharing), personal and working relationships, mutual trust, shared empowerment, mutual understanding and well-defined objectives. However, my research findings add three more key factors which were not clearly mentioned by both previous studies: adaptability between/among the collaborating participants, mutual respect and an innovation culture shared by the collaborating organisations.

8.3 CONTRIBUTIONS

My study contributes the body of knowledge to both design management theory and practice, particularly in the area of collaborative product development between/among multidisciplinary organisations at the micro level.

FOR THE BODY OF NEW KNOWLEDGE IN DESIGN MANAGEMENT AND STUDIES

- My study theorises a system epistemology of a creative network system for creativity and innovation in complex environments. It suggests a collaborative, decentralised and complementary model for product innovation, named collaborative networks of multidisciplinary organisations in the development of innovative products. This model derives from an interaction of my Thai cultural and Buddhist background, my professional design belief in a holistic design approach, and an understanding of the complex, dynamic processes of relating and cooperating derived from system, biological, social and complexity theories.

- In comparison with the comparative studies of Bruce et al (1995) and Sale and Wilkinson (1999), my study contributes to the following new knowledge:

  (i) In comparison with the study of Sale et al which studied a similar collaborative model to mine, my study focuses on the network relation; i.e. structural relations or invisible links which sustain the whole network relations and cooperations, rather than an individual action or a broker in managing collaboration. As a result, my study suggests key factors and aspects which uphold the relations and connections of the collaborating partners, rather than design management guidelines for a broker in managing the conditions of collaboration, as Sale et al suggested.

(ii) My research findings add three more key factors which have not been clearly suggested by both previous studies: adaptability between/among the collaborating partners, mutual respect and innovation culture of the collaborating partners.

The following research findings are the body of new knowledge added to design management theory, which has not been recommended by both previous studies:

(i) My study observes the level of mutuality of each critical factor and identifies the contextual characteristics of mutuality which could affect the effectiveness of the whole network, as mentioned in Section 8.1.3.

(ii) My study suggests 'solution-based guidelines', as mentioned in Section 8.1.2, which would help collaborating partners to understand the relationships between a set of critical factors and their effects and the interrelations of the critical factors.

(iii) My study suggests a set of four key categories of significant factors, as mentioned in Section 8.1.4, which would help collaborating partners to manage the relationship and behaviour of the collaborative network.

FOR PRACTICAL RECOMMENDATIONS TO INDUSTRY

- My research findings, as mentioned in Section 8.1.1 to 8.1.6, would help a team of collaborating partners in the following aspects:

(i) To cultivate, maintain, and/or deepen the effectiveness of the collaborative network relations and cooperations between/among multidisciplinary organisations during product innovation process

(ii) To observe, analyse and/or prevent problems and conflicts which would devalue the result of innovative products, delaying the collaborative network, leading to the collaborative network failure,

and affecting future working relationship between/among organisations.

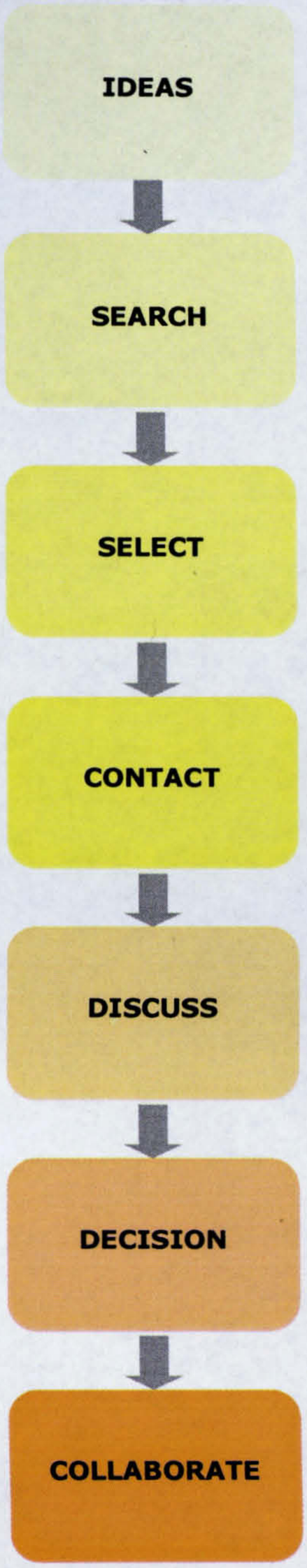
8.4 REFLECTIONS

During the investigation of the four network case studies, there are some important issues that emerged. There are also some pitfalls and barriers which other researchers could avoid in the future. My study reflects on the following topics: the establishment of a collaborative network, the status quo of case study, organisation characteristics, and research methodology.

8.3.1 THE ESTABLISHMENT OF A COLLABORATIVE NETWORK

The four network case studies reflect the pattern of the establishment process of contractual collaborative networks. The establishment process of a collaborative network is shown in Diagram 8-3.

Diagram 8-3 illustrates the establishment process of contractual collaborative networks



Stage 1. The idea identification process
Organisations identify new opportunities in developing innovative products, such as problems of existing products, innovative ideas from new technology, and market gaps.

Stage 2. The searching process
Organisations search for their collaborative partners. The sources are, for example journals, written papers and public domain documents, recommendations, public conferences, and some governmental projects.

Stage 3. The selection process
Organisations select their potential collaborative partners by looking at criteria, such as their required skills, knowledge, expertise and/or geographical proximity.

Stage 4. The contacting process
Organisations contact and communicate with potential collaborative partners.

Stage 5. The discussion & negotiation process
Organisations discuss details of partners and collaboration, such as partners' abilities, working processes, IPR, collaborative benefits, collaborative time scale, and other relevant issues related to collaboration.

Stage 6. The decision process
Organisations choose appropriate collaborative partners. My research findings suggest that collaborative partners should have both right capabilities and mindsets.

Stage 7. The collaboration process
Collaborative organisations interact with each other to develop innovative products. To work efficiently, collaborative organisations should act upon my research findings in Section 8.1.1 – 8.1.4.

8.3.2 THE STATUS QUO OF NETWORK CASE STUDY

My study suggests that collaborative networks of multidisciplinary organisations in the development of innovative products are dynamic and complex. Regarding complex, dynamic relating within the processes of collaborative networks, I adopt Stacey's theory, 'Complex Responsive Processes of Relating', the dynamics of communication and power relation of individuals in an organisation as the perpetual emergence of individual and organisational identities, as the direction for this analysis (Stacey, 2003). Based on this perspective, my study suggests that the communicative interacting, and power relating of collaborating individuals and organisations within collaborative networks create evolving patterns of individual and network identities which lead to the successful collaboration together. As a result, I elaborate three recurring issues illustrate the dynamic nature and complexity of the existence of each network case study.

First, the success of collaborative networks of multidisciplinary organisations in the development of innovative products is always based on hidden, interwoven interactions and connections of different dimensions. Adopting the framework of the study of organisational behaviour, referred by Mullins (2002) and Buchanan and Huczynski (2004), as the direction of this analysis, I identify four key dimensions:

- ☐ The personal dimension. Issues surrounding the personal dimension include: personality, personal chemistry, personal relationships and personal adaptability
- ☐ The organisation dimension. Issues surrounding the organisation dimension include: organisational attitudes towards collaboration, Top Management commitment and support, culture of each organisation and the abilities of each in-house team.

- ☐ The collaborative process dimension. Issues surrounding the collaborative process dimension include: product development process, communication protocol between/among the collaborative organisations, and the collaborative goals and objectives.
- ☐ The strength of working relationships. Issues surrounding the strength of working relationships include: mutual benefits, complementary interests and understanding one another.

My study suggests that each dimension strengthens other dimensions. They all sustain each other to create the emergent property of successful collaboration. Managing these four dimensions as interdependent entities would enhance the effective performance of the behaviour of collaborative networks.

Secondly, successful collaboration is a dynamic one. The structure of collaborative interactions and connections is constantly changing. For instance, the dynamics of communication and the dynamics of relationships between the collaborative teams affect the whole collaborative process.

Thirdly, each network case study has its own entity. Each network case study has its own identities: (1) communication structure, (2) interaction and connection process, (3) personal relationship structure, (4) attitudes towards collaborative networks, (5) value judgement towards collaboration, and (6) collaborative project timing.

8.3.3 ORGANISATION CHARACTERISTICS

Regarding my empirical study, two main types of organisation are identified: (i) experienced collaboration and (ii) less experienced collaboration.

The first category comprises organisations who have well-established and accumulated experience of external collaboration, i.e. BAE Systems and Cambridge Design Partnership. They understand and know-how to collaborate with other organisations. Fundamentally, they have a clear policy and a culture of collaboration within internal organisations and with external organisations. The outcome from the research questions reflects critical factors from various views. The experienced collaborators concern on and are aware of most of the key factors. For the advantage, they can provide clear and thorough information in what are factors for successful collaboration.

The second category comprises organisations who have little or no experience in external collaboration, i.e. RCL and Org A (Case Study 3). These organisations in my survey did not have a policy, guidelines or principles of collaboration. Their collaboration was based on 'enjoyment, good feelings and instincts'. These organisations can reflect both positive and negative experience, particularly on negative experience coming from errors of decisions and actions due to lack of experience. They were not aware of the key factors implied in the research questions. These questions helped them to recall and assess their collaborative experience. On the other hand, they were able to provide rich information about both strengths and weaknesses.

8.3.4 PROBLEMS DURING MY RESEARCH

My study encountered difficulties, problems and constraints during the empirical study. Along this process, the research tool and method needed some adjustment in order to accommodate more viable perspectives. Three main problematic issues were addressed by this process: (i) my research position, (ii) network case study approach, and (iii) sensitive issues surrounding the development of innovative products.

8.4.3.1 MY RESEARCH POSITION

The first problematic issue is my research position. Regarding the empirical network case study, my research position is as an outsider who does not participate in any parts of collaboration. This position has both disadvantages and advantages. **Disadvantages**: It was not possible to access the detailed collaborative process and collect all the significant evidence that would have given full clarity. For example, it was impossible to access legal contracts and documents about the design development process and the details of innovative products in respect to levels of the innovation process. It also was very difficult to get permission to access required information of each network case study because of the issues of product information sensitivity and authorisation in each collaborative network. For example, in the issue of authorisation, every network case study has an authoritative body whom my study needs to get permission to access the case. For instance, in Case Study 1, my study needed to get permission from BAE Systems before Case Study 1 would be able to be investigated. Unfortunately, in some cases, Case Studies 3 and 4, I contacted, at the beginning, organisations which were not the authoritative body. These organisations were willing to participate in my research. However, they would not allow me to contact their partners. This is because, for example, in Case Study 3, there was an issue of product confidentiality which is bound by the legal contract. In Case Study 4, there was an issue of 'unpleasant experience' during the collaboration. Therefore, these organisations did not want me to have further contact with their partners. Conformed by research ethics, my study have to respect the decisions of the research participants. **Advantages**: I can analyse all evidence of the collaborating organisations' viewpoints without any biases.

8.4.3.2 NETWORK CASE STUDY RESEARCH APPROACH

The second problematic issue is the network case study approach. In the theoretical perspective, it is an ideal approach to investigate all collaborating

organisations within a network. In the empirical study, this approach was very difficult because my study needed to understand the interactions, connections and communications between multidisciplinary organisations through individual levels, not organisation levels per se. This is because each individual had his/her entity of value judgement and limited perception regarding one's position in the organisation and network. For example, first, a research participant had a role as an in-house project leader and a main point of contact within the network. This participant could reveal his/her experience, information and reflection at the operational project level. He/she can provide research information, such as details of working process and their project experience. Secondly, a research participant had a role as Managing Director and a supervisor in organisations and participates within the network. This person could reveal his/her experience, information and reflection at the managerial level. He/she can provide research information, such as overview of collaborative networks and organisation policy and support. As a result, to access reliable information, other researchers need to get information from the right person.

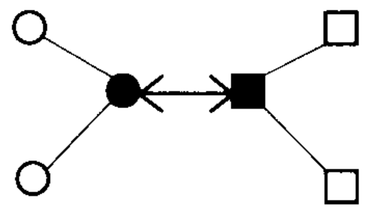
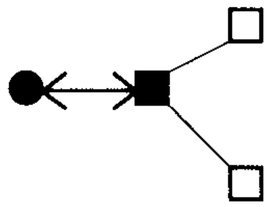
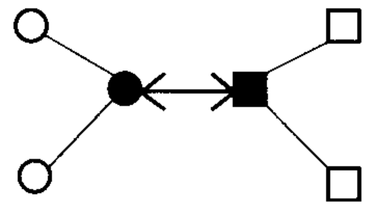
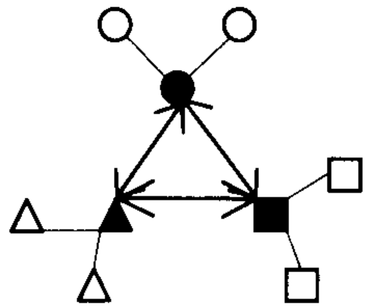
8.4.3.3 SENSITIVE ISSUES

The third problematic issue is the sensitive issue surrounding the development of innovative products within collaborative networks. As my study was aware of, approaching the existing network case study related to the development of innovative products is involved with the sensitive issue concerning innovative product information. To protect it, I decided to select the network case study where innovative products have been sold in the market. I believed that this decision would reduce the difficulty in accessing required research information. However, my study experienced another unexpected sensitive issue: the sensitivity between organisation relationships, as mentioned in Case Study 4. Because there were problems and conflicts experienced by an organisation during the collaborative network, the request to access the details of other collaborative

parties was declined by the organisation that my study approached. Therefore, to investigate such network case study, other researchers need to concern on the sensitive issues not only innovative product information, but also organisation relationships.

APPENDIX 8

Table 8-1shows a collection of the critical factors from the four network case studies

CASE STUDY 1	CASE STUDY 2	CASE STUDY 3	CASE STUDY 4
 **Overview of Structure of Collaborative Team 1**	 **Overview of Structure of Collaborative Team 2**	 **Overview of Structure of Collaborative Team 3**	 **Overview of Structure of Collaborative Team 4**
1. Mutually complementary interests 2. Mutual benefits 3. Mutual trust in the abilities between the main points of contact 4. Mutual trust between the collaborative partners across organisations 5. Clear, well-defined legal agreement 6. Good working relationship (especially, good interpersonal relationship between the main points of contact) 7. Joint problem-solving 8. Informal working process 9. Colleagues and equality of working relationship	1. Good interpersonal relationship between the main points of contact 2. Good working relationship between the collaborative team across organisations 3. Open information sharing between the main points of contact 4. Effective approach of communication, especially informal communication between the main points of contact 5. Mutual trust in the abilities between the main points of contact 6. Adaptability between the main points of contact 7. Clear, well-defined collaborative objectives	1. Good interpersonal relationship between the main points of contact 2. Mutual trust in the abilities between the main points of contact 3. Mutual trust between the collaborative team across organisations 4. Effective informal communication between the main point of contact 5. Effective informal communication between the collaborative team across organisations 6. Commitment between the main points of contact 7. Commitment of the collaborative team across organisations 8. Commitment of the in-house team 9. Equality of working relationship between the main points of contact	1. Mutual trust between the main points of contact 2. Mutual trust between the collaborative team across organisations 3. Mutual respect between the main points of contact 4. Mutual respect between the collaborative team across organisations 5. Mutual understanding the distinctive roles and responsibilities between the main points of contact 6. Mutual understanding the distinctive roles and responsibilities between the collaborative team across organisations 7. Clear, well-defined collaborative objectives and agreed goals

CASE STUDY 1 (Continued)	CASE STUDY 2 (Continued)	CASE STUDY 3 (Continued)	CASE STUDY 4 (Continued)
10. Informal, flexible and short-term planned collaborative design process 11. Effective approach of both informal and formal communication, especially between the main point of contact 12. Open information sharing between the main points of contact 13. Mutually clear understanding about the objective and requirement of collaboration 14. Mutually understanding other collaborating parties' skills and distinctive characteristics 15. The right partner should have both the right capabilities and mindsets 16. Open information sharing of the collaborative across organisations 17. Commitment of the collaborative team across organisations 18. Innovative abilities of each in-house team 19. Top management commitment and support 20. Well support from the leader within the in-house team 21. Good working environment within the in-house team 22. Innovation culture of organisation	8. Flexible approach during the collaborative design development process 9. Clear agreement of the benefits 10. Collaborative attitude (Understanding each other's requirements, problems, viewpoints and intentions) 11. Joint problem-solving (on critical design issues) 12. Joint decision-making (on critical design issues) 13. Commitment of the collaborative team across organisations 14. Top management commitment and support 15. Each in-house efficient abilities 16. Innovation culture of organisation	10. Clear agreement of benefits 11. Collaborative attitude (understanding other collaborating parties' distinctive abilities, drives, expectations, constraints and benefits) 12. Open information sharing between the main points of contact 13. Flexible structure of the collaborative design and development process (interaction and communication process 14. Adaptability of the collaborative team across organisations 15. Joint decision-making 16. Innovative abilities of in-house team 17. Innovation culture of each organisation 18. Flexibility of in-house team 19. Top management commitment and support	8. Mutual benefits 9. Joint decision-making 10. Clear, effective communication protocol between the collaborative team across organisations 11. Innovative culture of each organisation 12. Effective formal communication between the main points of contact 13. Open information sharing between the main points of contact 14. Open information sharing between the collaborative team across organisations 15. Mutual commitment between the main points of contact 16. Mutual commitment between the collaborative team across organisations 17. Commitment of in-house team 18. Adaptability between the main point of contact (communicative language) 19. Equal working relationship between the main points of contact 20. Flexible approach of collaborative design development process 21. Innovative abilities of in-house team 22. Top management commitment and support (each organisation)

Table 8-2 illustrates a collection of the important factors from the four case studies

CASE STUDY 1	CASE STUDY 2	CASE STUDY 3	CASE STUDY 4
1. The adaptability of each in-house team 2. Effective communication between the collaborative team 3. Joint-decision making (the decision depends on the initiator)	1. Innovative abilities of each in-house team	1. Joint problem-solving 2. Adaptability between the main points of contact 3. Clear, well-defined collaborative objectives 4. Close relationship of the collaborative team 5. Open information sharing of the collaborative team 6. Effective formal communication 7. Each organisation structure	1. Good interpersonal relationship between the main points of contact 2. Close relationship of the collaborative team 3. Joint problem-solving (Not all problems need to be solved jointly. However, each problem should have the right stakeholders) 4. Adaptability between the collaborative team 5. Effective informal communication between the main points of contact 6. Effective informal communication between the collaborative team 7. Effective formal communication between the collaborative team 8. Each organisation structure

Table 8-3 illustrates a collection of the benefits of mutual trust in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF MUTUAL TRUST
1	(1) Strengthens working relationship (2) Helps to save time and money (3) Mutual trust on a personal level strengthens mutual trust on an organisation level
2	(1) Supports the self-confidence of the collaborative project (2) Allows open connections and interactions
4	(1) Effects information sharing –such as without it causes less open information sharing, withheld information and modified information

Table 8-4 illustrates a collection of the benefits of good interpersonal relationship in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF GOOD INTERPERSONAL RELATIONSHIP
1	(1) Helping in sharing and exchanging ideas and information openly (2) Building up mutual trust and respect (3) Promoting long-term relationship (towards friendship) (4) It is a basis of all successful work
2	(1) Talks openly about problems and how to solve them (2) Building up partners' confidence (3) Helping the ease of working together (4) Supporting 'productive' collaboration and the quality of design solution (5) Promoting long-term collaboration (towards friendship) (6) Supporting mutual respect of abilities of each other
3	(1) Supporting the progression of the collaborative project

Table 8-5 illustrates a collection of the benefits of equal valuing of working roles in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF EQUAL VALUING OF WORKING ROLES
1	(1) Motivating the partner team (2) The collaborative team can assimilate and learn more from the project
4	(1) It is a basic concept of collaboration (2) Relating to respect

Table 8-6 illustrates a collection of the benefits of mutual respect in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF MUTUAL RESPECT
1	(1) Building up working relationship (2) Decreasing working problems and conflicts
4	(1) Supporting trust and openness

Table 8-7 illustrates a collection of the benefits of clear agreement of collaborative benefits in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF CLEAR AGREEMENT OF COLLABORATIVE BENEFITS
1	(1) Decreasing working problems (2) Strengthening commitment during the collaborative process
2	(1) Preventing problems which may happen if the project fails
4	(1) Effecting each party commitment in the project –commitment in the project might not be equal, if it is not equally shared benefits.

Table 8-8 illustrates a collection of the benefits of effective communication protocol in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF EFFECTIVE COMMUNICATION PROTOCOL
1	(1) Helping to save time and work more effectively and efficiently (2) Enabling openness in communication and discussion on difficult issues (3) Helping to avoid frustration
2	(1) Protecting the project go off track (2) Keeping update and monitoring the project (3) It is a basis for successful collaboration
3	(1) Being a core approach to deal with the collaboration, especially informal communication

Table 8-9 illustrates a collection of the benefits of flexible collaborative product development process in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF FLEXIBLE ARRANGEMENT DURING COLLABORATIVE DESIGN DEVELOPMENT PROCESS
1	(1) Sustaining long-term collaborative project
2	(1) Facilitating value-added recommendations which would increase the value of an end product. (2) Enhancing creativity
3	(1) Being able to attain the product dead line (2) Producing good quality of innovative products

Table 8-10 illustrates a collection of the benefits of clear, well-defined collaborative objectives and goals in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF CLEAR, WELL-DEFINED COLLABORATIVE OBJECTIVES AND GOALS
1	(1) Avoiding the disappointment and misunderstanding which destroy most relationship (2) Causing the difficulty of relationship
2	(1) It is fundamental for successful collaboration (2) If not, may cause a problem –such as over budget spending
4	(1) Being able to loosen the working system towards informal working system rather than formal

Table 8-11 illustrates a collection of the benefits of open information sharing in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF OPEN INFORMATION SHARING
1	(1) Being able to communicate effectively (2) Protecting failures of delivering solutions and supports (3) Sustaining joint activities (4) Building up mutual trust
2	(1) Reducing any problems during the collaboration (2) Flagging up problems quickly (3) Giving feedback to collaborative team to make them work properly (4) Building up trust

Table 8-12 illustrates a collection of the benefits of collaborative attitude in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF COLLABORATIVE ATTITUDE
1	(1) Avoiding mutual disappointed between collaborative parties
2	(1) Facilitating and optimising effective collaboration as a whole
3	(1) Facilitating willingness to see others' viewpoints
4	(1) Contributing what is required from each individual role

Table 8-13 illustrates a collection of the benefits of commitment at all levels in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF COMMITMENT OF THE WHOLE COLLABORATIVE TEAM
1	(1) Empowering the whole collaborative network (2) Sustaining collaboration (3) Helping to build up long-term relationship
2	(1) Facilitating the project progression (2) Contributing to the good result of innovative products

Table 8-13.1 illustrates a collection of the benefits of Top Management commitment of each organisation in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF TOP MANAGEMENT COMMITMENT
1	(1) Increasing encouragement to work, network and/or collaborate with external organisations (2) Motivating and giving confidence to in-house team in the collaborative project
2	(1) Allowing the project to be started (2) The determination to make project success (3) Maintaining the company viability and enable growth

Table 8-14 illustrates a collection of the benefits of adaptability in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF ADAPTABILITY
2	(1) Supporting effective collaboration
3	(1) Supporting willingness within the collaborative teams to change
4	(1) Strengthening collaboration

Table 8-15 illustrates a collection of the benefits of joint problem-solving in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF JOINT PROBLEM-SOLVING
1	(1) Helping motivation (2) Saving time in solving problems (3) Helping to work more effectively
2	(1) If there is a mistake in a serious problem, it wastes time and money (2) Avoiding the problem getting worse (3) Helping to initiate new ideas
3	(1) Supporting the creation of the best solution of innovative products

Table 8-16 illustrates a collection of the benefits of joint decision-making in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF JOINT DECISION-MAKING
1	Not critical
2	(1) If one-sided decision is wrong, it wastes time and expense
3	(1) Supporting the feasibility of end product and cost constraints
4	(1) It is a-must issue.

Table 8-17 illustrates a collection of the benefits of innovative abilities of each in-house team in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF INNOVATIVE ABILITIES OF EACH IN-HOUSE TEAM
1	(1) Strengthening innovation culture
2	Not critical. Case study 2 mentions efficient abilities of in-house team is critical.

Table 8-18 illustrates a collection of the benefits of innovation culture of each organisation in the successful collaborative network in the development of innovative products

CASE STUDY	THE BENEFITS OF INNOVATION CULTURE OF ORGANISATION
1	(1) Providing encouragement and support
2	(1) Stimulating the partner excitement and making the partner confidence (2) Being a key to gain market share (3) Leading company success
4	(1) It is a foundation on which all good behaviour is built within the team and organization

Table 8-18.3 illustrates the cross-case analysis of mutuality level of each key factor

FACTORS	KEY FACTORS	LEVEL OF MUTUALITY				
		CASE1	CASE2	CASE3	CASE4	AVERAGE
Adaptability	Adaptability of the in-house team	Low (2.5)	Med (3)	High (4)	High (4)	Med (3.37)
	Adaptability of the collaborative team	-	-	High (4)	Med (3)	Med (3.5)
	Adaptability between the main points of contact	-	-	Med (3)	High (4)	Med (3.5)
	Adjustment of communicative language between the main points of contact	-	-	Med (3)	High (4)	Med (3.5)
Commitment	Top Management commitment and support	High (4.25)	Med (3.5)	High (4)	High (4)	Med (3.94)
	Commitment of the collaborative team	High (5)	High (4.5)	High (5)	High (4)	High (4.62)
	Commitment between the main points of contact	-	-	High (5)	High (4)	High (4.5)
	In-house team commitment	-	-	High (5)	High (4)	High (4.5)
Communication	Effective communication between the collaborative team	Med (3.5)	Med (3)	-	-	Med (3.25)
	Effective communication with your partners' representatives	High (5)	High (4.75)	-	-	High (4.87)
	Effective informal communication between the collaborative team	-	-	High (5)	Med (3)	High (4)
	Effective formal communication between the collaborative team	-	-	Med (3)	Med (3)	Med (3)
	Effective informal communication between the main points of contact	-	-	High (5)	Med (3)	High (4)
	Effective formal communication between the main points of contact	-	-	Med (3)	High (4)	Med (3.5)
	Ability to communicate well between the main points of contact	-	-	High (4)	High (4)	High (4)
Well-organised process	Well-planned product development process	Low (2.5)	Med (3.5)	Med (3)	High (4)	Med (3.25)
	Flexibility of collaborative product development process	-	-	Med (3)	High (4)	Med (3.5)
Reciprocity	Open information exchange	High (4)	High (5)	-		High (4.5)
	Open information exchange between the main points of contact	-	-	High (4)	High (4)	High (4)
	Open information exchange within the collaborative team	-	-	Med (3)	High (4)	Med (3.5)
	Mutual benefits of the collaborative project	-	-	High (4)	High (5)	High (4.5)
Relationship	Good interpersonal relationship with your partners' representatives	High (4)	High (4.5)	-	-	High (4.25)
	Close working relationship with your partners' teams	Med (3)	Med (3.5)	Med (3)	Med (3)	Med (3.12)
	Good interpersonal relationship between the main points of contact	-	-	High (5)	Med (3)	High (4)
	Equal working relationship between the main points of contact	-	-	High (4)	High (4)	High (4)
	Open-mindedness between the main points of contact	-	-	High (5)	High (4)	High (4.5)
	Amicable personality between the main points of contact	-	-	High (4)	Med (3)	Med (3.5)
Self-regeneration	Innovative abilities of your in-house team	Med (3.25)	Med (3)	High (5)	High (4)	Med (3.81)
	Innovation culture of your organization	High (4)	Med (3.5)	High (5)	High (5)	High (4.37)
Shared empowerment	Joint problem-solving concerning new products	High (4.5)	Med (3.5)	Med (3)	Med (3)	Med (3.5)
	Joint decision-making concerning new products	No (1.75)	High (4)	High (4)	High (5)	Med (3.68)

FACTORS (Continued)	KEY FACTORS	LEVEL OF MUTUALITY				
		CASE1	CASE2	CASE3	CASE4	AVERAGE
Trust	Trust in the abilities of the partners	High (5)	High (5)	-	-	High (5)
	Trust in the abilities between the main points of contact	-	-	High (5)	High (5)	High (5)
	Mutual trust in the abilities of the collaborative team	-	-	High (5)	High (4)	High (4.5)
New factors emerging from the case studies						
Respect	*Mutual respect between the main points of contact*	-	-	High (4)	High (5)	High (4.5)
Collaborative attitude	*Understanding the distinctive roles of each other between the main points of contact*	-	-	Med (3)	High (5)	High (4)
	Mutual understanding the distinctive abilities of the collaborative team	-	-	High (4)	High (5)	High (4.5)
Determinate objective	*Clear, well-defined collaborative objectives*	-	-	Med (3)	High (5)	High (4)

Remarks: Normal letter is key factors used as standard for all Case Studies
Italic letter is 'added-in' key factors used for Case Study 3 and 4
The level value of mutuality: 4-5 = High, 3-3.99 = Medium (Med), 2-2.99 = Low, 1-1.99 = No Mutuality

SECTION 8.1.4

Table 8-19 illustrates a collection of the critical factors in roles and personalities of the main point of contact from the four case studies

CASE STUDY 1	CASE STUDY 2	CASE STUDY 3	CASE STUDY 4
1. Developing good personal relationship 2. Being able to understand the external partners' knowledge and roles 3. Establishing the effective methods of communication between the collaborative team across organisations 4. Being efficient mediator (promoting and supporting the benefits of this collaboration to Top management) 5. Applying the by-product of the collaborative research to develop the better in-house products	1. Adapting the communicative language 2. Building up personal relationship 3. Ability to communicate well 4. Being friendly and efficient mediator 5. Being efficient mediator between internal and external team 6. Respecting other collaborating teams' abilities 7. Understanding others' distinctive roles 8. Communicating openly and honestly	1. Open-mindedness 2. Ability to communicate well 3. Amicable personality 4. Respecting others 5. Trusting others 6. Building up personal relationship 7. Commitment 8. Communicating openly	1. Trusting others 2. Respecting others 3. Understanding distinctive roles of others 4. Ability to communicate well 5. Communicating openly 6. Open-mindedness 7. Commitment 8. Being adaptable 9. Adjustment of communicative language

Table 8-20 illustrates a collection of the important factors in roles and personalities of the main points of contact from four case studies

CASE STUDY 1	CASE STUDY 2	CASE STUDY 3	CASE STUDY 4
Na	Na	1. Understanding the distinctive roles of others 2. Adjustment of communicative language 3. Being adaptable	1. Amicable personality 2. Building up personal relationship

Table 8-21 illustrates a collection of critical links between the collaborating organisations from the four case studies

CASE STUDY 1	CASE STUDY 2	CASE STUDY 3	CASE STUDY 4
1. Complementary interest 2. Mutual benefits 3. Personal relationship 4. Complementary knowledge 5. Efficient communication protocol 6. Collaborative attitudes/ mindsets	1. Agreed benefits 2. Personal relationship 3. Complementary skills and knowledge 4. Efficient communication protocol 5. Collaborative attitude	1. Complementary interest 2. Agreed benefits 3. Complementary skills and knowledge 4. Personal relationship 5. Efficient communication protocol 6. Collaborative attitude	1. Complementary skills and knowledge 2. Unequal shared benefits 3. Lack of collaborative attitude 4. Lack of clear communication protocol

SECTION 8.1.5

Table 8-22 illustrates a comparison between critical factors of Case studies 1 – 3 which have the different durations and the sixteen critical factors of the research findings of all case studies

Collaborative product Development duration	96 months continuously	15 months	3 months
SIXTEEN CRITICAL FACTORS	**CASE STUDY 1**	**CASE STUDY 2**	**CASE STUDY 3**
1. Mutual Trust	*	*	*
2. Good interpersonal relationship	*	*	*
3. Equal valuing of working	*	*	*
4. Mutual respect	Mentioned	Mentioned	Not mentioned
5. Clear agreement on the collaborative benefits	*	*	*
6. Effective communication protocol	*	*	*
7. Flexible collaborative product development process	*	*	*
8. Clear, well-defined collaborative objectives and goals	*	*	✦
9. Open information sharing	*	*	*
10. Collaborative attitudes (Mutual understanding)	*	*	*
11. Commitment at all levels	*	*	*
12. Adaptability	✦	*	*
13. Joint problem-solving	*	*	✦
14. Joint decision-making	✦	*	*
15. Innovative abilities of each in-house team	*	✦	*
16. Innovation culture of each organisation	*	*	*

Remarks: * means the key factor was valued 'CRITICAL'
✦ means the key factor was valued 'IMPORTANT'
Mentioned means the critical factor was mentioned during the data collection
Not mentioned means the critical factor was not mentioned during the data collection

Table 8-23 shows the roles of the network initiators and collaborators of the four case studies

CASE STUDY	1	2	3	4
A NUMBER OF THE COLLABORATING ORGANISATIONS	2	2	2	3
INITIATORS	BAE Systems	Remote Controlled Lighting Ltd.	Org. B (Manufacturing Organisation) Remark: No access	Org. B (Manufacturing Organisation) Remark: No access
COLLABORATORS	Nottingham University	Cambridge Design Partnership (CDP)	Org. A (Technology Organisation)	(i) Org. A (Design Consultancy) (ii) Org. C (Technology Organisation) Remark: No access

Table 8-24 illustrates a collection of the critical factors from the network initiators' views

CASE STUDY 1'S INITIATOR	CASE STUDY 2'S INITIATOR
The success from collaboration (1) Mutual benefits (2) Complementary skills (3) Good personal and working communication (4) Mutual understanding of the intrinsic nature of work and skills between partners (5) Clear, well-defined goal and agreements (6) Right capability and mindset (7) Mutual benefits **Within in-house team and organisation** (1) Ability to communicate well and openly (2) Good organisational structure (3) Having good, strong research department (4) Mutual trust (5) Making sure support of Top Management **The main point of contact** (1) To promote and strongly support the development of this partnership (2) To use the research information for developing the highly successful project	**The success from collaboration** (1) Clear goal (2) Relationships (3) Collaborative attitude (understanding others' viewpoint) (4) Efficient abilities of both partners **Within in-house team, organisation and as the main point of contact** (1) Commitment, determination and support (2) Good abilities of in-house team

Table 8-25 illustrates a collection of the critical factors from the collaborators' views

CASE STUDY 1	CASE STUDY 2	CASE STUDY 3	CASE STUDY 4
Within the collaboration (1) Mutual interest (2) Good working relationship (3) Clear agreement of benefits (4) Confidence in each other **In-house team/organisation** (1) Good people in the team (2) Well support from the team leader (3) Good team environment (4) Building up external contact related to in-house team work	**Within the collaboration** (1) Communication (2) Complementary skills and knowledge (3) Understanding others' problems (4) Good personal relationship **In-house team/organisation** (1) Friendliness (2) Being approachable (3) A clear brief (4) Regular meeting between everyone in the team **The main point of contact** (1) Being approachable (2) Openly and honestly communicate (3) Friendly, efficient point of contact (4) Good understanding of what in-house team members are capable of (5) Sufficient technical knowledge	**Within the collaboration** (1) Understanding other parties' distinctive abilities, drives and benefits **In-house team/organisation** (1) Understanding what the project wants (2) Understanding on what the end product must achieve **The main point of contact** (1) Ease of working with others (2) To make sure the collaborating team striving at the same goal	**Within the collaboration** (1) Clear goals of each organisation to get involved (2) Clear communication protocol **In-house team/organisation** (1) Efficient abilities of in-house team, such as creating prototypes frequently **The main point of contact** (1) Clear organisation roles and responsibilities (2) Clear project plan

Diagram 8-1 illustrates the mapping of the critical factors and their effects

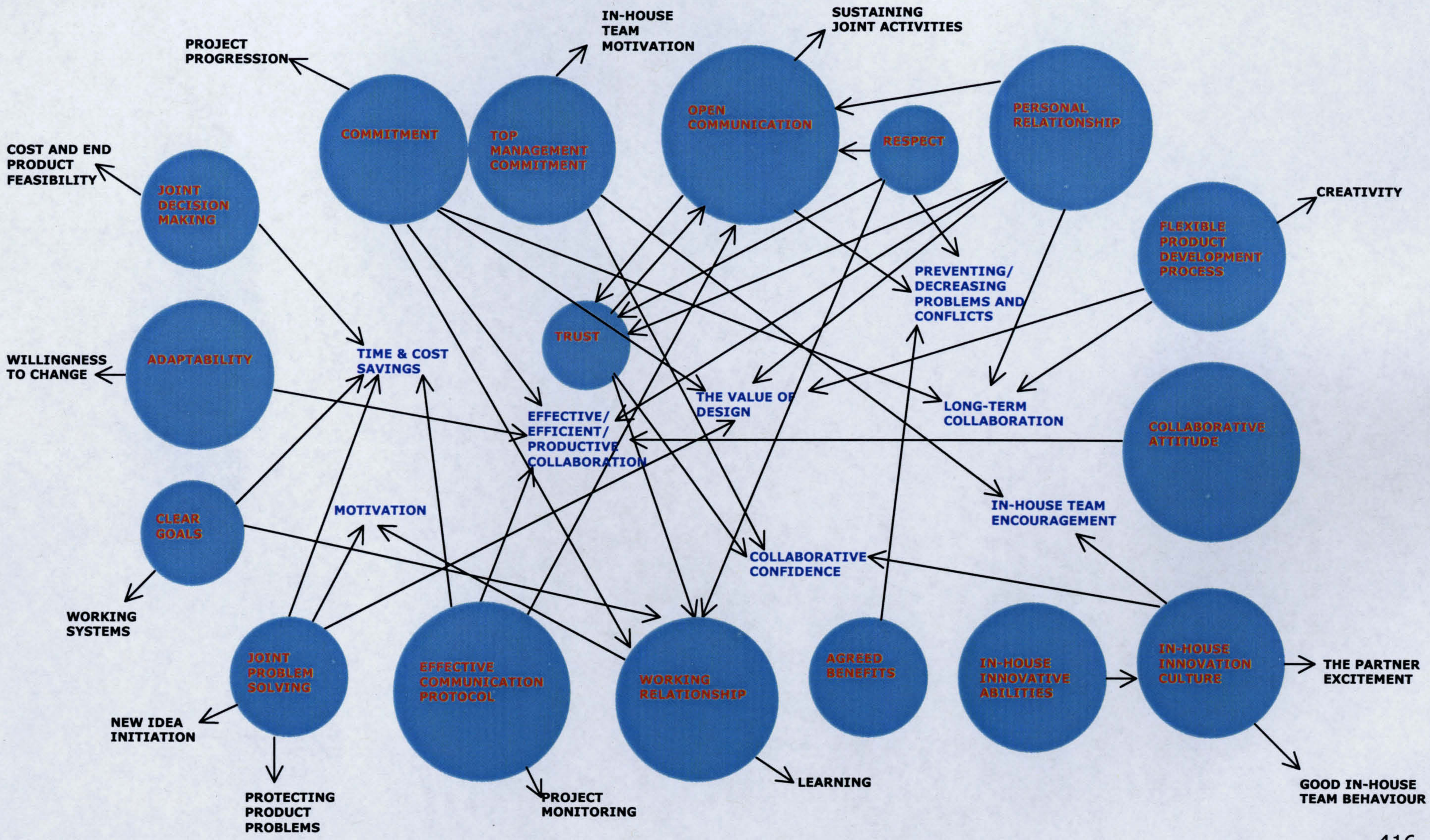
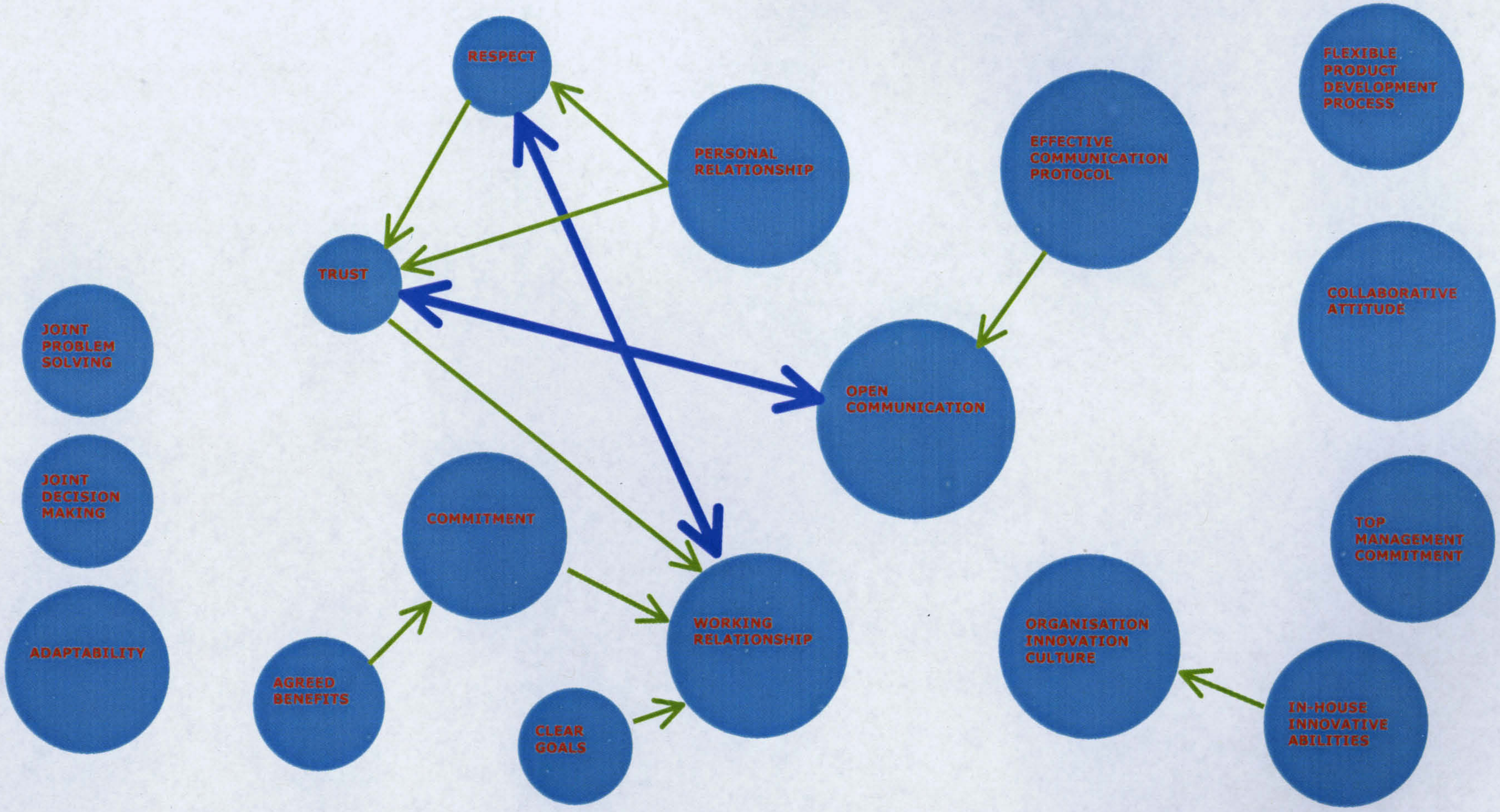


Diagram 8-2 illustrates the mapping of relationships between the critical factors



GLOSSARY

TERMS	MEANING
A main point of contact	*A representative of an organisation, who works closely with other organisations' representatives as a main point of contact.*
Autopoiesis	*Autopoiesis is 'the self-generation [self-making] of living networks' (Capra, 2002, 30). Capra describes that 'the defining characteristic of an autopoietic system is that it undergoes continual structural changes while preserving its web-like pattern of organization.'*
Bodhisattva	*A bodhisattva is a being that is actively striving toward that goal. Conventionally, the term is applied to hypothetical beings with a high degree of enlightenment and power.*
Collaborative attitude	*Collaborative attitude is defined as mutual understanding between the collaborative parties*
Contractual collaborative projects	*The collaboration of at least two non-directly competitive, multidisciplinary organisations that are contractually committed to work together by means of sharing their efforts in the development of an innovative product.*
Coupling	*Maturana and Valera (1980, 136) defines coupling as 'the conduct of two or more unites is such that the conduct of each one is the function of the conduct of the others.'*
Critical	*In this thesis, critical doesn't mean 'absolutely essential'. Critical means very significant. Lacking of these critical factors may cause problems, perils, ineffectiveness and/or failures during collaborative networks.*
Mutuality	*Mutuality is defined as having or based on the same relationship one towards the other. For example, the collaborating organisations A and B have mutual trust. (=Org A trust Org B and Org B trust A)*
Network	*Network is defined as a system of interacting parts and their relations.*
Network collaborator	*A network collaborator is an organisation which is selected and decides to join a collaborative network*
Network initiator	*A network initiator is an organisation which decides to build up a collaborative network*
Open Systems	*Open systems are systems which are considered to interact with their environment. Based on Von Bertalanffy's General System theory (Von Bertalanffy, 1969), 'living organisms are…open systems.' (32) 'It [a living organism as a open system] maintains itself in a continuous inflow and outflow, a building up and breaking down of components, never being,…in a state of chemical and thermodynamic equilibrium but maintained in a so-called steady state…' (Von Bertalanffy, 1969, 39). Von Bertalanffy suggested two main characteristics of open systems: (i) the principle of equifinality (the same final state may be reached from different initial conditions and in different ways) and (ii) the principle of maintaining themselves in a steady state.*
Reciprocity	*Reciprocity is defined as the activities of giving and receiving in return. Reciprocity refers to the activity of exchange which does not need to act simultaneously. For example, the collaborating organisations share information with each other.*

TERMS (Continued)	MEANING
Relational links	*Relational links are defined as relational structure which links the collaborating organisations together. The examples of relational links are personal relationship, complementary resources, shared interest and mutual benefits.*
Self-organising	*Self-organising is defined as the autonomous ability of complex systems to organise itself. For example, Capra (1982, 290) mentions that 'a living organism is a self-organizing system which means that its order in structure and function is not improved by the environment but is established by the system itself.'*
Structural coupling	*Maturana and Varela (1987, 75) defines Structural Coupling as the interaction between two units within the environment consists of reciprocal perturbation.*
Togetherness	*Togetherness refers to the action which the collaborative team needs to act together simultaneously and/or cooperatively in order to reach a resolution. For example, Org A and B solve problems related to an innovative product together.*
TCS	*TCS stands for Teaching Company Scheme. The aim of this project is to encourage knowledge transfer through people. It supports for graduates to work on innovative projects in firms.*
Link	*The aim of this programme is to support research collaborations between firms and universities*
SMART	*The aim of the SMART scheme is to fund towards the costs of R&D projects in SMEs*
Faraday Partnerships	*This scheme is funding of knowledge transfer networks. It aims to promote flows of people, technology and innovative business concepts between the science and engineering base and industry*

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APPENDICES

DESIGN INNOVATION NETWORKS:
CRITICAL FACTORS THAT CAN CONTRIBUTE TO SUCCESSFUL COLLABORATIVE DEVELOPMENT OF INNOVATIVE PRODUCTS

C. BUSSRACUMPAKORN

PhD THESIS

LONDON UNIVERSITY
GOLDSMITHS COLLEGE
DEPARTMENT OF DESIGN

2006

APPENDICE CONTENTS

APPENDIX A:

DATA COLLECTION MATERIALS: PILOT STUDY 1

A-1: THE EXAMPLE OF COVERING LETTER

Mr John Hornsby
Dynamic Healthcare Limited
Eanam Wharf, Blackburn Waterside
Blackburn, Blackburn BB1 5BL

Ref.: OSS081

10 July 2001

Dear Mr Hornsby

I am a PhD research student in the Design Department at Goldsmiths College, University of London, looking at design innovation among collaborating companies. I wish to communicate with Millennium Products prize winners because they share a concern for innovative design. Your company was chosen after reviewing information published by the Design Council.

The enclosed questionnaire is designed to be completed within about 4-6 minutes, and I should be most grateful if you would please complete it, and return it in the provided, stamped envelope before 15th August.

I confirm that the questionnaire is absolutely confidential. I will abide by sound ethical procedures as a researcher and any information will be used for academic purposes only.

Thank you very much for your valuable time and kind assistance to fill in the questionnaire.

Yours sincerely

Chokeanand Bussracumpakorn

Design Department, Goldsmiths College,
University of London
13 Laurie Grove
New Cross, London
SE14 6NH
Tel. 0207 919-7171 Ext. 4052
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Email: dtp01cb@gold.ac.uk

A-2: THE EXAMPLE OF QUESTIONNAIRE 1

:

Contact ID: .

Product Name:

CONFIDENTIAL QUESTIONNAIRE

LINKS WITH OTHER ORGANISATIONS SUSTAINING INNOVATIVE DESIGN

Please answer questions 1 – 10 from your company viewpoint/experience on the award winning design mentioned name above.

Please place a tick in the box ☐, following the introduction of each question

1 Please choose [illegible] would best describe your company's design activities.

1☐ Offering completely new, unique, and different design
2☐ Offering highly innovative design for specific users
3☐ Combining user needs and technology availability to offer new improved design
4☐ Highly improving functions, appearance and quality in your design
5☐ Offering a updated version of the previous product
6☐ Other (please specify).....

2 Please choose [illegible] which you might take [illegible] the award winning design.

1☐ Opening up new business opportunities
2☐ Challenging existing conventional design
3☐ Wanting to be a design leader in the market
4☐ Wanting to be a business leader in the market
5☐ Offering design that responsive to human needs
6☐ Incorporating new technology that may lead your company in new direction
7☐ Encouraging individual empowerment in your company
8☐ Supporting in-house design team
9☐ Employing design consultants
10☐ Demonstrating environmental responsibility
11☐ Wanting to improve quality of life
12☐ Responding to market
13☐ Other (please specify).....

3 Please choose [illegible] reference to the award winning design.

1☐ User needs
2☐ Problems of existing products in the market
3☐ Market research
4☐ User Environment
5☐ Environmental responsibility
6☐ Competitors
7☐ High/advanced technology
8☐ Legal issues
9☐ In-house creative ideas
10☐ Emergent new knowledge
11☐ Funding
12☐ Future trends
13☐ Social interests
14☐ Other (please specify).....

4 [illegible] following sources with [illegible] to the [illegible] award winning design.

1☐ Research Institutions (universities and laboratories)
2☐ Competitors
3☐ Production Suppliers (new technologies of components and systems)
4☐ Knowledgeable organisations as co-suppliers
5☐ Distributors
6☐ Retailers
7☐ Market research organisations
8☐ Governmental specialist organisations
9☐ Innovation centres
10☐ Financial institutions
11☐ Legal advisors
12☐ User groups
13☐ Design consultants
14☐ Professional designers
15☐ Other (please specify).....

5 [illegible] following reasons why [illegible] award winning design.

1☐ To access specialised knowledge
2☐ To access specialised skills
3☐ To reduce R&D cost
4☐ To share risk and liability
5☐ To obtain training
6☐ To accrue technology transfer benefits
7☐ To speed up the innovation process
8☐ To improve in-house creativity
9☐ To improve design appearance
10☐ Other (please specify).....

6. Would you please describe your company's [illegible] established links with other organisations?

Please place a tick in the appropriate column

7. For each phase of the product development process, please indicate the award winning factors that you consider important for your company to [illegible]

	Very Important	Important	Of Little Importance	Not Important
1 Research and development				
2 Idea and concept generations				
3 Concept research				
4 Concept testing				
5 Market research				
6 Market testing				
7 Manufacture				
8 Distributions				
9 Services				
10 Disposal				
11 Other (please specify)				

Please place a tick either YES, UNCERTAIN, or NO for the following questions:

8. Did your company [illegible]

☐ Yes ☐ Uncertain ☐ No

9. [illegible]

☐ Yes ☐ Uncertain ☐ No

10. [illegible]

☐ Yes ☐ Uncertain ☐ No

Please answer the questions 11 – 16 from your current professional viewpoint/position

Would you please give your opinions on the following statements by placing a tick in the appropriate column

	(5) Strongly Agree	(4) Agree	(3) Uncertain	(2) Disagree	(1) Strongly Disagree
11. [illegible]					
12. [illegible] organisations will [illegible]					
13. [illegible]					
14. [illegible] will [illegible]					
15. [illegible] organisations would [illegible]					
16. [illegible]					

(i) .....

.....

.....

(ii) .....

.....

.....

(iii) .....

.....

A-3: THE ANALYSIS OF PILOT STUDY 1

23rd October 2001

The Networks of Design Innovation:
LINKS WITH OTHER ORGANISATIONS SUSTAINING INNOVATIVE DESIGN

RESEARCH CASE STUDY

Millennium Products' Award winning companies.

This award was initiated by The Design Council in September 1997, There are 1012 innovations awarded during 1997-2000. The award winning designs were based on creativity and innovation, which was shown in many means:

- Opening up new opportunities
- Challenging existing design conventions
- Demonstrating environmental responsibility
- Using new or existing technology
- Solving a key problem
- Showing clear user benefits

A focus group of companies for the case studies are selected from the Design Council categorisation on the 'Innovation issues/processes'. There are totally 26 issues/processes, such as Brianwave-Driven, Environmental Push, Futures & Forecasting, Links with other Organisations, University Links and User Needs.

The case studies are selected up one issue, 'Links with other organisations'. There are 255 innovative designs in this issue. It is the fifth rank from a total number.

Table 1. This table shows the innovation issues/processes that the companies employed them in the achievement of innovative design in ranking from one to five.

Rank	Innovation Issues/Processes	No. of Innovations
1	User needs	423
2	Market testing	391
3	Problem solving	355
4	Market research	326
5	**Links with other organisations**	**255**

The research selects 138 innovations (mainly on innovative products) of small and medium sized companies to analyse on 'how' and 'why' the companies need to link with other organisations in generating innovative design. The research chooses a postal questionnaire to be the second approach after getting the grounded theory from literature reviews.

POSTAL QUESTIONNAIRE DESIGN

During April – September 2001, my purpose of sending out the postal questionnaire is to as the following:

- To study the existing phenomenology of the network, which is affecting and relating to innovative design

- To select a case study for in-depth research (on any aspect in managing innovative design)

The postal questionnaire designed consists of two main parts: (1) design/company information and (2) design/company visions. The first section (10 questions) aims to analyse companies' experience when was initiating the award winning design. The questions draw on the following respects:

- What the considerations of the company were in generating the award winning design
- Why the company needed to link with other organisations (as the network) in generating the award winning design
- How the company established the network
- What the strategic network contributed to the innovative design
- Which sources the company linked up in contributing to the achievement of the award winning design
- At which stage in each product innovation process the company importantly linked up with other organisations
- What the type of the network for the award winning design is

The second section aims to analyse company attitudes on the employment of the strategic network in the future. The statements are constructed on the company opinions and beliefs employing the strategic network in supporting innovative design, speeding up new design to market, increasing design resources, enhancing the company in-house creativity and changing the way in doing business. Moreover, the research enquires specific opinions as to 'why linking with other organisations contributes to the company design visions'.

All respondents are the chairperson involving mainly with 'the award winning design' and a part of decision makers in company policy and strategy in design. The position in the company is generally 'Managing Director', 'Research, Development and Design Director/Manager and/or Technical Director/Manager.

Therefore, the postal questionnaire was designed on the following criteria:

- Spending less time to fill in (this questionnaire is about 4-6 minutes)
- Most answers are constructed as a tick-box answer

THE POSTAL QUESTIONNAIRE RESULTS

138 questionnaires were sent out. 77 questionnaires were returned back before the analysis started around the middle of September. 1 questionnaire returned back after the analysis has started. The rate of response is 55.8% (77 questionnaires). The rate of the undelivered questionnaires is 5% (7 questionnaires).

Question 1, from 77 innovations, there are 68 designs (88%) which fall into the research criteria of innovative design. The research criteria of innovative design are as the following:

- Offering completely new, unique and different design
- Offering new design concept
- Offering highly innovative design for specific users
- Combining user needs and technology availability to offer new improved design

The examples of innovative design following the criteria are:

1. Tribopen: 'a hand held device that provides a solution to the problem of discriminating between very similar types of plastics' (Offering new, unique and different design)
2. FSM-IT (Field Signature Method Inspection Tool): 'a non intrusive monitoring/inspection system which can determine very small changes in metallurgy due to corrosion/erosion on pipework' (offering new design concept)
3. Discam: a camera for detecting glaucoma by looking into the rear of the eye (offering highly innovative design for specific users)
4. Airwedge: an inflatable air bag assembly for the crash recovery of new generation aircraft with complex wing angles, particular airbus A340 and Boeing B777 (Combining user needs and technology availability to offer new improved design)

Regarding the analysis of the **question 2**, as shown in Table 2 below, there are five core factors influencing the companies to sustain innovative design: new business opportunities, human needs, design, market and new technology. Here is extracted from the questionnaire as the following:

- Opening up *new business opportunities* (65%)
- Offering new design that responsive to *human needs* (45%)
- Challenging existing conventional *design* (42%)
- Want to be business leader in the *market* (40%)
- Responding to *market* (38%)
- Incorporating *new technology* that may lead your company in the new direction (36%)

Table 2 illustrates the percentage of internal factors influencing the companies to sustain innovative design

Internal Factors	Frequency	Percentage (N=77)
Opening up new business opportunities	50	65%
Offering design that responsive to human needs	35	45%
Challenging existing conventional design	32	42%
Wanting to be business leader in the market	31	40%
Responding to market	29	38%
Incorporating new technology that may lead your company in the new direction	28	36%
Wanting to be design leader in the market	23	30%
Wanting to improve quality of life	23	30%
Demonstrating environmental responsibility	11	14%
Supporting in-house design team	6	8%
Employing design consultants	5	7%
Encouraging individual empowerment in your company	3	4%
Other (Result of university based R&D)	1	1%

Regarding the analysis of the question 3, as shown in Table 3 below, the findings suggest that 'user needs' (84%) and 'problems of existing products in the market' (70%) have a high percentage in inspiring creative thinking in the company. The issues of 'in-house creative design' (45%) and 'high/advanced technology' (43%) show a medium percentage. The issues

having a low percentage are environmental responsibility (18%), legal issues (16%) and social interests (13%).

Table 3 illustrates the percentage of the inspiring issues in reference to the award winning design.

Inspiring issues	Frequency	Percentage (N=77)
User needs	65	84%
Problems of existing products in the market	54	70%
In-house creative design	35	45%
High/advanced technology	33	43%
Market research	27	35%
Competitors	27	35%
Emergent new knowledge	27	35%
Future trends	24	31%
Funding	21	27%
User environment	18	23%
Environmental responsibility	14	18%
Legal issues	12	16%
Social interests	10	13%

Regarding the analysis of the **question 4**, the findings reveal external sources with which the companies linked in the contribution to the achievement of innovative design. In the analysis of a number of external sources with which the company linked, it is ranging from 10 to none. The findings suggests *most companies linked with one or two external sources*. One company linked with 10 sources (code HAL045) including research institutions, competitors, production suppliers, knowledgeable organisations as co-suppliers, distributors, market research organisations, legal advisors, user groups, design consultants and professional designers. The description of design is 'a revolutionary drug delivery system that uses Adaptive Aerosol Delivery (AAD) technology to deliver precise and reproducible drug dose to the lungs, HaloLite'.

As a part of external sources analysis, two core sources: Research Institutions (universities and laboratories) and Production Suppliers (new technologies of components and systems) reveals higher percentage in comparison with other external sources. The details are shown in Table 4 below:

The result from the Table 4 shows less than one-fifth percent in employing design consultants (16%) and professional designers (15%) was contributing to innovative design. This raises further question 'who is defined as 'designers' in the network'. This would be every company within the network presenting design capabilities.

Table 4 illustrates the percentage of the external sources with which the companies linked in contributing to the achievement of the award winning design

External Sources	Frequency	Percentage (N==77)
Research institutions (Universities and Laboratories)	35	47%
Production suppliers (New technologies of components and systems)	31	42%
Distributors	17	23%
User groups	15	20%
Governmental specialist organisations	13	18%
Knowledgeable organisations as co-suppliers	12	16%
Design consultants	12	16%
Professional designers	11	15%
Retailers	8	11%
Innovation centres	8	11%
Legal advisors	6	8%
Competitors	5	7%
Market research organisations	5	7%
Financial institutions	3	4%
Customers	3	4%

Remark: N (The total number of frequency) =74

Regarding the analysis of the **question 5**, as shown in Table 5 below, there are five management reasons in managing innovative design by linking with other organisations: in-house resource management, time management, cost management, risk management and design management. The details are shown as the following:

- Resource management
  - to access specialised knowledge (code1)
  - to access specialised skills (code 2)
  - to obtain training (code 5)
  - to accrue technology transfer benefits (code 6)
- Time management
  - to speed up the product innovation process (code 7)
- Cost management
  - to reduce R&D cost (code 3)
  - to get funding
- Risk management
  - to share risk and liability (code 4) *'what risk in managing innovative product by using the networking strategy is' such as intellectual property, product success, and so on.*
- Product/design management
  - to improve design appearance (code 9)
  - to test/evaluate product
  - to ensure the product meets users' need

Table 5 illustrates the percentage of reasons why companies linked with other organisations

Reasons	Frequency	Percentage (N=77)
To access specialised knowledge	52	68%
To access specialised skill	30	39%
To speed up the innovation process	29	38%
To reduce R&D cost	23	30%
To accrue technology transfer benefits	14	18%
To improve design appearance	14	18%
To improve in-house creativity	9	12%
To share risk and liability	6	8%
To test/evaluate product	5	6%
To get funding	4	5%
To obtain training	2	3%
To ensure the product meet users' needs	1	1%
To form opinion	1	1%
To follow company objectivity and process	1	1%

Regarding the analysis of the open-ended **question 6**, there are eleven categories of how the companies established links with other organisations as shown in the Table 6 below:

Table 6 illustrates means companies established their links

External sources	A number of responded answers
Through directing contact for specific purposes	23
Through long-term personal and professional relationships	16
Through the existing network: local supplier networks and Internet	11
Through attending public events: competitions, seminars, exhibition, and conference	10
Through government initiative schemes: Teaching Company Scheme (TCS), Business Links, DTI Link projects, and all funded projects	10
By recommendations	4
Through regular involvement with academic	3
Through publication	3
Through marketing research	2
Through being members of design groups	1
Through using Management Technology Centre	1

As the analysis of the **question 7**, the networking strategy shows the important effect to six issues in the product innovation process: research and development, idea and concept generations, concept research, concept testing, market research and market testing. The analysis is shown in Table 7 below:

Table 7 illustrates the value of the networking strategy in the product innovation process

Code	Product Innovation Process	Score	Mean
1	Research and development	230	2.99
2	Idea and concept generations	184	2.39
3	Concept research	143	1.86
4	Concept testing	187	2.43
5	Market research	162	2.10
6	Market testing	168	2.18
7	Manufacture	181	2.35
8	Distributions	133	1.73
9	Services	122	1.58
10	Disposal	91	1.81
11	Others (Product testing)	7	-

The networking strategy crucially demonstrates in the incubation stage (design planing) in the product innovation process. *This would direct the next step of research on 'the networking strategy and innovative design planning'.*

Regarding the analysis of the **question 8**, as shown in Table 8 below most companies did not form collaborative networks (53%). They used the networking strategy as 'a way to acquire specific needs from external sources. Nonetheless, 39% of the respondents formed the collaborative network.

Table 8 illustrates the percentage of organisations forming collaborative networks

Answer of Question 8, Did your company link with other organisations to form collaborative network?	**Frequency**	**Percentage (N=77)**
Yes	30	39%
No	41	53.2%
Uncertain	6	7.8%

The explanation of the horizontal network and the vertical network is clarified by the information from literature reviews. The horizontal network is the network that an organisation links with other external sources in various aspects. For example, the automotive industry links with the electronic industry, the digital technology industry, and the aerospace industry. The vertical network is the network that an organisation links with other external resources by concerning the main activities that the organisation needs. For example, within the automotive industry, there are several links with the external sources in developing automotive products, such as automotive engine organisation, automotive part organisation and new material organisation. Regarding the analysis of the **question 9**, as shown in Table 9 below, 73% of the organisations has formed the vertical network in generating innovative product/design. 22% of the organisation has formed the horizontal network. Table 9 illustrates the percentage of organisations linking with other across industry

Answer of Question 9, Did your company link with other organisations across many different industries?	**Frequency**	**Percentage (N=77)**
Yes	17	21.1%
No	56	72.7%
Uncertain	4	5.2%

The research sets up the hypothesis of the network form which might influence innovative design. The research compares the answers of the question 9 of each organisation that answered 'yes' with the question 1 (the characteristics of the award winning design). 94% (16 companies from the total of 17 companies) of the organisations forming the horizontal network generates innovative product/design. 85.7% (48 companies from the total of 56 companies answering 'No' in the question 9) of the organisations uses the vertical network in generating innovative product/design. *This would conclude that the network form does not have any relation with innovative design.* This raises the question, *'what are the real needs in managing innovative design within the network'? This would be reflected from the organisational design policy, strategy, culture, working processes, communication, decision making and teamworking with external sources.*

Regarding the analysis of the **question 10**, as shown in Table 10 below, most companies (71.4%) had not collaborated regarding design planning. Nonetheless, one-fifth of the companies did collaborate for the design planning. The research is interested in a small group of the companies that have used the collaborative network for design planning.

Table 10 illustrates the percentage of organisations collaborating with other organisations regarding design planning

Answer of Question 10, Was your company collaborating with other organisations with regard to design planning	**Frequency**	**Percentage (N=77)**
Yes	15	19.5%
No	55	71.4%
Uncertain	7	9.1%

From the question 8-10, three companies (MMS070, FSM039 and GOR043) answered 'yes' with all the questions. The research analyses these results with the question 4 to consider a number of the external sources in contributing to the achievement of the award winning design. At the same time, the research looks at the result from the question 4 of the highest number of the external sources with which the organisation linked and considers the answers in the question 8-10. The details are shown in the following Table 11 below:

Table 11 illustrates the results of the question 8-10 and the result of a number of the external sources in the question 4

Company Code	**Answers**			**A Number of the External Sources**
	Q.8	**Q.9**	**Q.10**	
MMS070	Yes	Yes	Yes	5
FSM039	Yes	Yes	Yes	6
GOR043	Yes	Yes	Yes	1
*HAL045	Uncertain	Yes	Yes	10
SCO103	Yes	Uncertain	Yes	7

From the Table 11, four companies (MMS070, FSM039, HAL045 and SCO103) might be selected to study in-depth about **'how the organisations use the networking strategy (mostly by using external sources) for innovative design planning.**

Section 2: Design/Company vision

The second part of the postal questionnaire aims to measure the attitudes of the company on linking with other organisations in generating innovative design in the future. The questions was focusing on links with other organisation that will be on the following aspects:

- Supporting 'innovative design' in products, processes and/or services in the future (Question 11)

- Speeding up the transfer of innovative design to the market (reducing time in the product innovation process) (question 12)
- Generating of more innovative design (question 13)
- Encouraging in-house creativity (question 14)
- Changing the way the organisation does business (question 15)

Regarding the analysis of the questions 11-15, the findings reveal on Table 12 below.

Table 12 illustrates the company attitudes towards links with other organisations in the future

Attitudes	Mean	Percentage
Supporting 'innovative design'	3.83	76.6%
Speeding up the transfer of innovative design to the market	3.78	75.5%
Generating of more innovative design	3.70	73.9%
Encouraging in-house creativity	3.42	68.4%
Changing the way the organisation does business	3.65	73.7%

- All organisations show 'agree' attitudes on the benefits of linking with other organisations in supporting innovative design in the future: speeding up the design innovation process, generating more innovative design and changing the way the organisation does business.
- In-house creativity shows less unaffectedly on links with other organisations. Even though, most organisations do have the agreement on encouraging in-house creativity, the result shows the degree of uncertainty in this issue.

Regarding the analysis of the open-ended question 16, the result shows different aspects of the networking strategy that would contribute to design visions. Figure 1 illustrates all aspects:

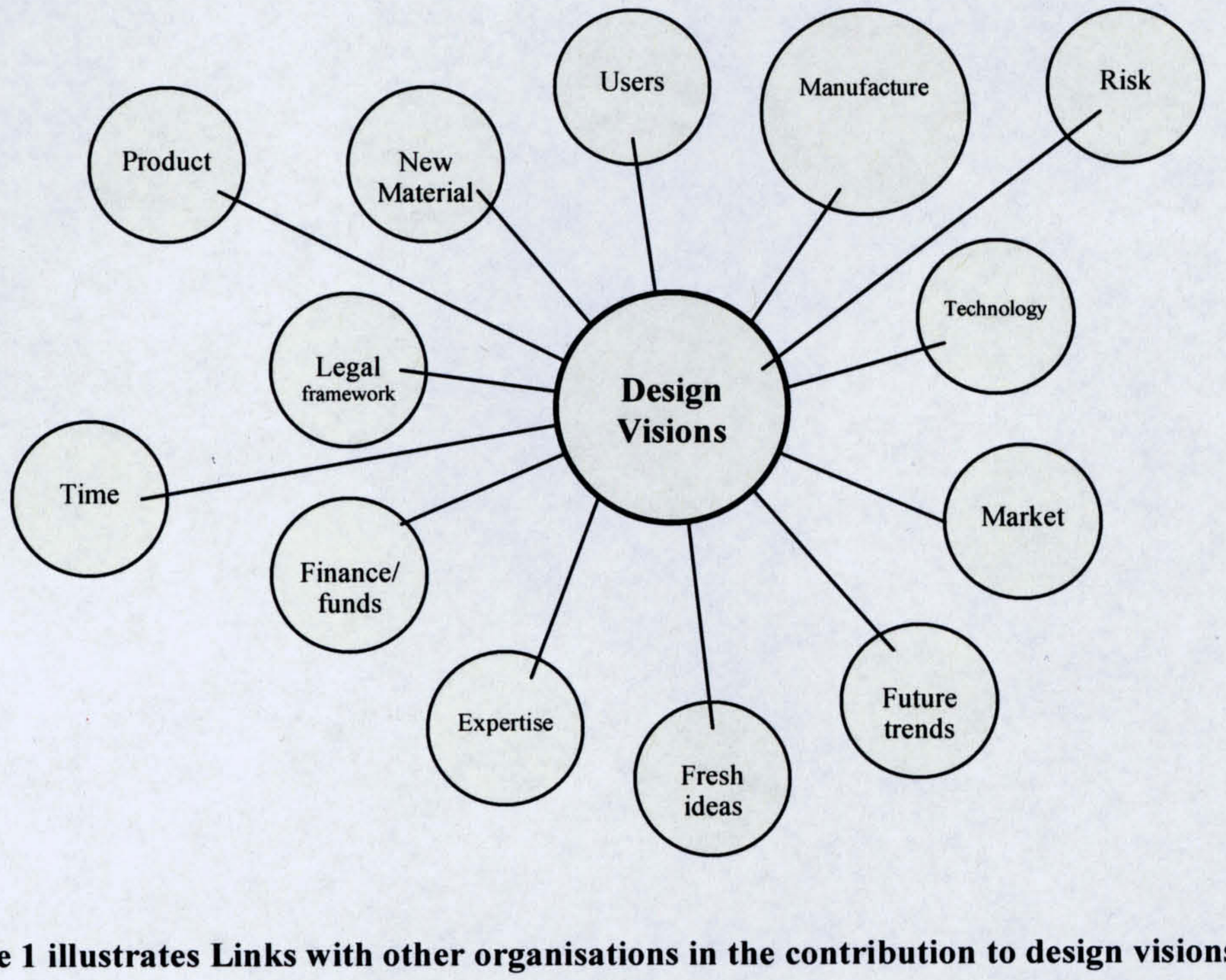

Figure 1 illustrates Links with other organisations in the contribution to design visions

The networking strategy provides many contributions to design visions as shown in Figure 1. Normally, design interfaces with many aspects, such as material, users, technology, market, future trends, expertise and fresh ideas. The details in each issue are presented as the following:

- Users, such as clear user requirement, judgement from users, accessing end-users problems and information and promoting user involvement
- Manufacture, such as production process and new fabrication process
- Technology, such as transferring and licensing technology
- Market, such as customer viewpoints, customer demands, accessing marketing expertise, market awareness, providing the potential customers and ensuring market acceptance of product.
- Future trends, such as future trends within industries
- Fresh ideas, such as challenging companies ideas, getting outside viewpoint, expanding ideas and sharing ideas
- Expertise, such as specific skills, resources, equipment, new knowledge (research), standardisation and new development
- Finance/Funds, such as reducing R&D costs, reducing cost in manufacturing process, strengthening financial framework internally in manufacturing and marketing feasibility in design, funding and financial assistance from design supportive organisation or governmental scheme
- Legal framework, such as patents and intellectual property and manufacturing and marketing of the product
- Material, such as new material and design changes in raw materials
- Risk, such as reducing risk in R&D
- Time, such as speeding up design to the market, R&D process and obtaining knowledge quickly
- Product, such as accessing the existing products, delivering the efficient product to users, getting fresh ideas from designers and design consultants, solving design problems, product testing in the market, product concept, confirming a solution of product need, identifying design needs, getting the best design solution, accessing the existing design knowledge, testing out design ideas to market place, achieving the best design, adding value to design and helping to define unique selling points of products.

There are some problems issued about the networking strategy in the questionnaire as the following:

1. *The constraints within university* made the connection not so successful
2. *We are small company, we need outside brain and manufacturing abilities*
3. *Generally, inventing is initially a secretive and lateral thinking process –after patent protection*
4. One organisation found no benefits in linking with other organisations so the product was developed in-house.
5. Links through funded projects is an absolutely negative because of bureaucracy
6. Theoretically, co-operation could be helpful. In practice, innovation is a lonely and difficult process.

APPENDIX B:

DATA COLLECTION MATERIALS: PILOT STUDY 2

B-1: THE EXAMPLE OF SMEs' COVERING LETTER

Forticrete Roofing Products
Heath Road
Leighton Buzzard
Bedfordshire LU7 8ER

Ref (SME): ZZG152

27 March 2003

Dear Mr. Lambert

I am a PhD research student in the Design Department at Goldsmiths College, University of London. I am writing this letter to thank you your assistance in the participation of my PhD survey research which was conducted during summer 2001, concerning "Links with other organisations sustaining innovative design. After the analysis of that survey, there is a missing piece of information which is a crucial part of my PhD research.

I would like your help in answering a few more questions in the enclosed questionnaire. The questionnaire, entitled "critical indicators within collaborative project success in the development of innovative products" is still related to your Millennium Award winning product. It is designed to be completed within 8-10 minutes. I should be most grateful if you would complete it and return it in the enclosed, stamped envelope before 20th Apr.

Your contribution will be very useful to establish invaluable both practical and theoretical knowledge in design and product innovation management. This knowledge about critical indictors would be used as practical guidelines for organisations to successfully and effectively work within collaborative projects to achieve the development of innovative products.

I confirm that the questionnaire is absolutely confidential, and that I will abide by sound ethical procedures as a researcher. Any information will be used for academic purposes only.

Thanking you in anticipation of your valuable time and kind assistance in completing the questionnaire.

Yours Sincerely

Chokeanand Bussracumpakorn
Design Department, Goldsmiths College
University of London
13 Laurie Grove New Cross, London
SE14 6NH
Tel. 0207 919-7171 Ext 4052
Email: dtp01cb@gold.ac.u

B-2: THE EXAMPLE OF DESIGN CONSULTANCY COVERING LETTER

Mike Beadman
Cambridge Design Partnership Ltd
The Old Horse Yard
Comberton Road
Toft, Cambridge CB3 7RY

Ref (DC): CDP-MB

26 March 2003

Dear Mr. Beadman

I am a PhD research student in the Design Department at Goldsmiths College, University of London. I am conducting a research focusing on **"critical indicators which lead to the successful development of innovative products within collaborative projects."** I wish to liaise with you as you have valuable practical experiences in collaborative projects with external organisations in the successful development of innovative products. I found your contact details when reading the recent case studies regarding innovative products published on your company website. These were of great interest to me in my area of research.

I would appreciate it if you could find time to answer the enclosed questionnaire. It is designed to be completed within 8-10 minutes. I shall be most grateful if you would complete it and return it in the enclosed, stamped envelope before 20th Apr.

Your contribution will help to establish invaluable both practical and theoretical knowledge in design and product innovation management. This knowledge about critical indicators would be used as practical guidelines for organisations to successfully and effectively work within collaborative projects to achieve the development of innovative products.

I confirm that the questionnaire is absolutely confidential, and that I will abide by sound ethical procedures as a researcher. Any information will be used for academic purposes only.

Thanking you in anticipation of your valuable time and kind assistance in completing the questionnaire.

Yours Sincerely

Chokeanand Bussracumpakorn
Design Department, Goldsmiths College
University of London
13 Laurie Grove New Cross, London
SE14 6NH
Tel. 0207 919-7171 Ext 4052
Fax. 0207 919-7783
Email: dtp01cb@gold.ac.uk

B-3: THE EXAMPLE OF SMEs' QUESTIONNAIRE 2

B-4: THE EXAMPLE OF DESIGN CONSULTANCY'S QUESTIONNAIRE 3

Contact ID (SMEs) **B-3**

Product Name CONFIDENTIAL QUESTIONNAIRE

CRITICAL INDICATORS WITHIN COLLABORATIVE PROJECT SUCCESS IN THE DEVELOPMENT OF INNOVATIVE PRODUCTS

Please place a tick in the box ☐ or write your answer, following the introduction of each question

1. **Regarding your award winning product, did your organisation collaborate with external organisations as *a collaborative project in the successful development of innovative products?**
(The collaborative project is defined as "a project in which at least two organisations work together as a team.")

1☐ YES **(If answer yes, please answer all of the following questions and then answer question 3 and 4)**

2☐ NO **(If answer no, please skip to answer question 2)**

1.1 When did the collaborative project start? 1☐1995 2☐1996 3☐ 1997 4☐Other(Please specify).....

1.2 When did the collaborative project complete? 1☐1997 2☐1998 3☐ 1999 4☐Other (Please specify).....

1.3 How many external organisations collaborated in the project? 1☐1 2☐2 3☐ 3 4☐Other (Please specify).....

1.4 Please give the name(s) of the external organisations with which your organisation collaborated:

.....

.....

.....

1.5 Did you work in the collaborative project? 1☐YES 2☐NO (Please skip to answer question 1.7)

1.6 What was your role in the organisation team when you collaborated with external organisations in the project?

1☐ a team leader as a main co-ordinator 2☐ a team member 3☐ Other (Please specify).....

1.7 Did the collaborative project have a contract? 1☐ YES 2☐ NO

2. **Has your organisation ever worked within collaborative projects with external organisations in the successful development of innovative products?**

1☐ YES **(If answer yes, please answer all of the following questions)** 2☐ NO **(If answer no, please skip to answer question 4)**

2.1 How many collaborative projects has your organisation joined since 1998?

1☐1-4 2☐5-8 3☐ 9-12 4☐over 12

2.2 Please give me brief details of one recent collaborative project success that your organisation joined with
(Please note, you should give an example of a recent collaborative project which is not commercial sensitivity)

- *Name of the project* .....
- *Description of the developed product* .....

.....

- *Start year of the project*: 1☐1998 2☐1999 3☐ 2000 4☐2001 5☐2002
- *How many external organisations did your organisation collaborate with in the project?*

1☐ 1 2☐ 2 3☐ 3 4☐ Other (please specify).....

- *Please give the name(s) of the external organisations with which you collaborated:* .....

.....

.....

- *Did the collaborative project have a contract?* 1☐ YES 2☐ NO

- *Did you work in the collaborative project?*

  1☐ YES (if answer yes, please answer the following question) 2☐ NO (if answer no, please skip the following question)

- *What was your role in the organisation team when you collaborated with external organisations in the project?*

  1☐ a team leader as a main co-ordinator 2☐ a team member 3☐ Other (Please specify).....

3. Regarding your experience, what do you think is critical to collaborative project success in the development of innovative products?

Please identify how importance the following are in your experience. Number them from 5=**extremely important**, to 1=**not important**

		5	4	3	2	1
1	Trust in the abilities of the partner's main co-ordinator					
2	Trust in the abilities of the partner's team					
3	Trust in the abilities of the partner's organisational reputation					
4	Understanding the distinctive abilities of the partner's team					
5	Close interpersonal relationship with the partner's main co-ordinator					
6	Close relationship with the partner's team					
7	Well-established, long-term relationship between organisations					
8	Open information exchange between the main co-ordinators of the project					
9	Open information exchange within the project team					
10	Sharing internal sensitive information from your organisation that innovative products need with the partner's team					
11	Sharing the changing external environment that innovative products need with the partner's team					
12	Open discussion about all issues that innovative products need within the project team					
13	Joint design problem solving in critical stages of the innovative product development process within the project team					
14	Joint design decision making in critical stages of the innovative product development process within the project team					
15	Top management support for the project					
16	Top management commitment to the project					
17	The project team's commitment to the project					
18	Well-planned innovative product development process in the project					
19	Effective communication between the main co-ordinators of the project					
20	Effective communication within the collaborative project team					
21	Strong culture of innovation/creativity within your organisation					
22	The independent innovative/creative abilities of your team members					
23	Free communication concerning innovative product issues with your other organisation members					
24	Flexibility of working systems within the project					
25	The adjustment of your team's working systems to suit the partner's team					
26	The adjustment of communicative language to be easily understandable for the partner's team					

4. Please give me your following details.

- Name .....

- The position in your organisation: .....

If you would not like me to mention your name and position in relation to writing and publications, please place a tick on this box ☐

Thank you so much for your time

CRITICAL INDICATORS WITHIN COLLABORATIVE PROJECT SUCCESS IN THE DEVELOPMENT OF INNOVATIVE PRODUCTS

Please place a tick in the box ☐ or write your answer, following the introduction of each question

1. How many people work in your organisation?

1☐1-20 2☐21-49 3☐50-99 4☐100-249 5☐over 250

2. Have you ever worked within *collaborative projects with external organisations in the development of innovative products? (*The collaborative project is defined as "a project in which at least two organisations work together as a team")

1☐ YES **(If yes, please answer all of the following questions)** 2☐ NO **(If no, please skip to answer question 4)**

2.1 How many collaborative projects have you joined since 1998?

1☐1-4 2☐5-8 3☐ 9-12 4☐over 12

2.2 Please give me brief details of one recent collaborative project success that you worked with

(Please note, you should give an example of a recent collaborative project which is not commercial sensitivity)

- *Name of the project* .....
- *Description of the developed product* .....

.....

- *Start year of the project*: 1☐1998 2☐1999 3☐ 2000 4☐2001 5☐2002
- *How many external organisations did you collaborate with in the project?*

  1☐ 1 2☐ 2 3☐ 3 4☐ Other (please specify).....
- *Please give the name(s) of the external organisations with which you collaborated:* .....

.....

.....

- *What was your role in the organisation team when you collaborated with external organisations in the project?*

  1☐ a team leader as a main co-ordinator 2☐ a team member 3☐ Other (Please specify).....
- *Did the project have a contract?*

  1☐ YES 2☐ NO

3. Regarding your experience, what do you think is critical to collaborative project success in the development of innovative products?

Please identify how importance the following are in your experience. Number them from 5=**extremely important**, to 1=**not important**

		5	4	3	2	1
1	Trust in the abilities of the partner's main co-ordinator					
2	Trust in the abilities of the partner's team					
3	Trust in the abilities of the partner's organisational reputation					
4	Understanding the distinctive abilities of the partner's team					
5	Close interpersonal relationship with the partner's main co-ordinator					
6	Close relationship with the partner's team					
7	Well-established, long-term relationship between organisations					
8	Open information exchange between the main co-ordinators of the project					
9	Open information exchange within the project team					
10	Sharing internal sensitive information from your organisation that innovative products need with the partner's team					
11	Sharing the changing external environment that innovative products need with the partner's team					
12	Open discussion about all issues that innovative products need within the project team					
13	Joint design problem solving in critical stages of the innovative product development process within the project team					
14	Joint design decision making in critical stages of the innovative product development process within the project team					
15	Top management support for the project					
16	Top management commitment to the project					
17	The project team's commitment to the project					
18	Well-planned innovative product development process in the project					
19	Effective communication between the main co-ordinators of the project					
20	Effective communication within the collaborative project team					
21	Strong culture of innovation/creativity within your organisation					
22	The independent innovative/creative abilities of your team members					
23	Free communication concerning innovative product issues with your other organisation members					
24	Flexibility of working systems within the project					
25	The adjustment of your team's working systems to suit the partner's team					
26	The adjustment of communicative language to be easily understandable for the partner's team					

4. Please give me your following details.

- Name: .....

- The position in your organisation: .....

If you would not like me to mention your name and position in relation to writing and publications, please place a tick on this box ☐

Thank you so much for your time

B-5: THE EXECUTIVE SUMMARY OF PILOT STUDY 2

Ms Tina Detheridge
Widgit Software Limited
102 Radford Road
Leamington Spa
Warwickshire CV31 1LF

25 June 2003

Dear Ms Detheridge

I am writing this letter to express thanks for your help in my PhD research during March 2003.

I would like to inform you of the result of my questionnaire research analysis. The postal questionnaire, entitled 'Critical Indicators within Collaborative Project Success in the Development of Innovative Products' was sent to 28 UK SMEs and 8 UK-based design consultancies that have experience on collaborative product innovation projects. The result has been analysed from 20 innovative product projects. The critical factors which underpinned the success in the collaborative development of innovative products between organisations are identified. These critical factors are categorised into two groups: (1) within the organisation and (2) within a collaborative project. The first group indicates three critical factors within the organisation as the following;

(i) **Top management commitment and support** for the collaborative project,
(ii) **Trust** in the abilities of collaborative partners,
(iii) Strong **culture of innovation/creativity**

The second group indicates five critical factors within a collaborative project as the following;

(a) **Effective communication** both between the project's main co-ordinators and within the project team
(b) The collaborative project **team's commitment**
(c) **Open information exchange** both between the project's main co-ordinators and within the project team
(d) **Open discussion** about all issues that innovative products need within the project team
(e) **Joint problem-solving** in critical stages of the product innovation process within the project team

If you would like to add further suggestions or comments regarding these findings, please fell free to do so by sending me an email. With your permission, I may contact you again to request your participation in an interview session which would be the final part of my research.

Thank you again for your help. It was greatly appreciated.

Yours sincerely

Chokeanand Bussracumpakorn
Design Department, Goldsmiths College University of London
13 Laurie Grove New Cross London SE14 6NH
Tel. 0207 919-7171 Ext 4052
Fax. 0207 919-7783
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APPENDIX C:

DATA COLLECTION MATERIALS: 4 CASE STUDIES

C-1: THE EXAMPLE OF COVERING LETTER

[CF]
BAE Systems (Operations) Limited at Plymouth

16 June 2003

Dear Sir

I am a PhD research student in the Design Department at Goldsmiths College, University of London. At the beginning of year 2003, I had talked to [Mr GO] by phone and asked for the permission to access the collaborative project between BAE Systems and Nottingham University in the development of Silicon Gyroscope as my PhD research case study. He introduced you to me as the key person who I need to talk to regarding this project.

I am writing this letter to request your help for participating an interview session in my research. My research is focused on critical factors which underpinned the success of the collaborative development of new products between organisations.

Herein, I enclose an introductory document explaining all details of my research. This document includes three main issues: 1) the research purpose, 2) the procedure of interview and 3) the use of interview.

I will contact you by phone in the near future to arrange your available time to interviewing. I would be grateful if you can provide your time during 30 June – 15 July 2003.

Thanking you in anticipation of your help.

Yours sincerely

Chokeanand Bussracumpakorn
Design Department, Goldsmiths College
University of London
13 Laurie Grove
New Cross, London
SE14 6NH
Tel. 0207 919-7171 Ext 4052
Fax. 0207 919-7783
Email: dtp01cb@gold.ac.uk

C-2: THE ENCLOSED INTRODUCTORY DOCUMENT

Research Title: **Networks of Design Innovation: Critical Indicators within Collaborative Networks for the Successful Development of Innovative Products**

Researcher: **Chokeanand Bussracumpakorn**
Design Department, Goldsmiths College, University of London
dtp01cb@gold.ac.uk, chokeanand@hotmail.com

SUMMARY OF INITIAL RESEARCH

To date, my study has conducted an extensive investigation of product innovation development success, and the successfully managed organisational networks. Findings suggest ten hypothetical indicators and one hypothesis which would be critical in the successful development of innovative products within collaborative networks:

(1) trust in the abilities of collaborative partners,
(2) close interpersonal relationship,
(3) open information exchange,
(4) joint problem solving,
(5) Joint decision-making,
(6) commitment to innovative product project,
(7) well-organised collaborative process,
(8) effective communication between participating functions,
(9) individual innovative abilities,
(10) working system adaptability, and
(11) In addition to the above ten indicators, a high level of mutuality between collaborative organisations is essential.

Thus, the purpose of this thesis is to examine these findings through the investigation of empirical case studies. In order to survey the field, the study selected contractual collaborative projects as the case study model. Based on my research findings, most of the UK industrial organisations prefer to use a legal contract during collaborative product innovation process.

The purpose of the thesis is to show critical indicators which underpin the successful development of innovative products within contractual collaborative projects. In professional practice, these indicators will be used as collaborative product innovation management guidelines. Such guidelines would benefit the UK organisations as follows: (1) to plan managerial strategy, (2) to analyse the organisational performance, (3) to prevent and control hidden causes which would lead to the failure of collaborative product innovation projects, and (4) to sustain and maximise collaborative project performance.

THE RESEARCH PURPOSE

The study aims to examine critical indicators which underpin the successful development of innovative products within contractual collaborative projects. Regarding the synthesis of my previous research, ten hypothetical indicators and one hypothesis were identified. To examine these indicators and the hypothesis, case studies were chosen using the criteria below. Generally, the case study approach aims to qualitatively investigate critical issues in-depth. Three objectives are as follows:

- To examine qualitative factors which would be the most critical within contractual collaborative projects in the successful development of innovative products
- To define and ascertain specific aspects of qualitative, critical factors
- To examine the level of mutuality between collaborative organisations according to qualitative, critical indicators

CASE STUDY CRITERIA

Research case studies need to have three main criteria.

1. It is a contractual collaborative project, defined as *the collaboration of at least two non-direct competitive organisations that are contractually committed to work together as a team by means of sharing their efforts in the development of an innovative product.*

2. The project needs to create a successful new product, defined as *at least a viable prototype which could be mass-produced in industrial processes.*

3. The degree of new products needs to fit into one of the following main categories: i) new product to the world market or ii) highly improvements of existing products.

There are no specific types and areas of new products. They range from advanced technical products to incremental improvements of product components. Your collaborative project has been examined and selected from these specific research case study criteria.

INTERVIEW PROCEDURE

The interview period is approximately 60 minutes. There are two types of pre-defined questions: open-ended questions and close-ended questions. These pre-defined questions aim to examine critical issues underpinning the success of the collaborative product innovation project. **There is no objective intention to investigate neither secretive, technical details nor commercial sensitive information concerning new products.** Assessment cards will be used for the close-ended questions. With your permission, a tape recorder would be used during the interview to assist in writing up afterwards.

In addition, if you could suggest in the public domain any documents which are related to the collaborative project, the collaborative partners and the new product.

THE USE OF DATA FROM INTERVIEW

I confirm that I will abide by the following ethical procedures:

i. The interview will be used and published for academic purpose only. If the interview needs to be used for any other purposes, your permission will be sought.

ii. The interview transcription and interpretations will be sent to you to view before they are published.

iii. You have a right to full anonymity (such as, for persons, organisations and events)

If required, I can provide an official letter from the Postgraduate Research Administrator to confirm details and future use of this interview material.

EXECUTIVE SUMMARY

After completing my research, all participating organisations will receive an executive summary reporting case studies' research findings.

C-3: THE EXAMPLE OF INTERVIEW SCRIPT 1

C-4: THE EXAMPLE OF QUESTIONNAIRE 4

C-3 THE EXAMPLE OF INTERVIEW SCRIPT 1

Code **Date**

Project Name

Organisation

Interviewee

Place

Introduction

This study aims to examine underlying, critical factors which underpinned the success of new product collaboration between organisations. Regarding my position as academic researcher and an outsider of your collaborative project, who are interesting to investigate your retrospective experience and working procedures during the collaboration, therefore please help me answer any questions in details as much as you can, no matter how trivial or abstract the answers are, it will be essential for my study result.

Critical factors mean **the factors that are very significant. Lacking of these critical factors may cause problems, perils, ineffectiveness and/or failures during the collaboration.**

With your permission, tape recorder will be used during the interview

DON'T FORGET

- ☐ Do you have records or articles about this project that I could use in the public domain?

1. GENERAL QUESTIONS ABOUT THE ORGANISATION AND COLLABORATIVE TEAM

1.1 INTRODUCTION

☐ **How the collaborative project started?**

(i) Why you collaborated with your partners?

(ii) How well did you know your partners before the project started? (optional)

1.2 GENERAL ARRANGEMENT of/during COLLABORATION

☐ **How your organisation arranged the legal contract of this collaborative project?**

(i) What were essential agreements in the legal contract?

(ii) What benefits did your organisation get from this collaboration?

(iii) How the legal contract underpinned the success of the collaborative project?

☐ **How you arranged the collaborative working process with your partners?**

(i) What critical issues need to be concerned?

(ii) What were your company roles?

(iii) How many people mainly worked in the collaborative team across organisations?

(iv) Are you the main point of contact during the collaboration?

(v) Any problems or conflicts of this working arrangement? If yes, What and Why?

☐ **How you communicated with your partners during the collaborative project?**

(i) What methods? Both informally and formally and how often?

(ii) How effective of the methods?

(iii) Any Problems of communication? If yes. What and Why and how you solved it?

- **How open you shared information to your partners?**

(i) How open your partners shared information to you?

(ii) In your opinion, what was essential information for this new product?

- **Did you or your team need to adapt or adjust anything when you collaborated with your partners?**

(i) If yes. What and Why?

1.3 COLLABORATIVE DESIGN DEVELOPMENT PROCESS

- **Please tell me design development process during the collaboration**

(i) How was this process? (well-planned, informal, flexible and so on)

(ii) Who initiated this process? Who planned it?

(iii) Any problems or conflicts? What and why?

- **How the collaborative team across organisations solved design problems in the design process during the collaboration?**

- **How the collaborative team across organisations made decisions about the solution of new design?**

1.4 THE RELATIONSHIP BETWEEN THE COLLABORATIVE TEAM

- **How was the relationship between you and your partners' main points of contact?**

(i) How close your personal relationship with your partners' main points of contact was? (professional relationship or friendship)

(ii) How this relationship supported the success of collaboration?

- **How was the relationship between you and your partner's teams?**

1.5 IN-HOUSE TEAM

- **How many people worked in your in-house team for this collaborative project?**

(i) What they specialised?

(ii) How they worked and communicated?

(iii) Did they have a chance to communicate directly to your partners' teams?

(iv) Did they need to adjust or adapt anything for this collaborative project? If yes. What and why?

(v) As a team leader, how you managed and encouraged your team regarding this collaborative project?

1.6 YOUR ORGANISATION

- **How your organisation supported this collaboration?**

(i) Any special supports?

- **What is the culture of innovation of your organisation?**

(i) For instance, working environment and process, communication, motivation and so on

(ii) Do you think this culture supported the success of collaboration?

1.7 PROBLEMS DURING THE COLLABORATION

- **In general, did you have any problems or conflicts during the collaboration?**

(i) If yes. What and why?

- **If you could change or improve anything during the collaboration, what were you do? And WHY?**

2. IDENTIFYING CRITICAL FACTORS

- ☐ **What were underlying critical factors <u>in the collaborative team across organisations</u> which underpinned the success of new product collaboration? And Why?**

- ☐ **What were underlying critical factors <u>in your team and organisation</u> which underpinned the success of new product collaboration? And Why?**

- ☐ **Regarding your role as the main point of contact during the collaboration, in your opinion, what was your critical contribution that supported the collaborative project success?**

Critical Factors in Collaborative Project Success for New Products

3. MEASURING HYPOTHETICAL FACTORS

Please identify **how critical the following factors were which underpinned the success of new product collaboration** and **give me your reasons to support any answer.**

Please use assessment card A

HYPOTHETICAL FACTORS	Extremely Critical (5)	Very Critical (4)	Important (3)	Little Important (2)	Unimportant (1)	WHY?
1. Close interpersonal relationship with your partners' main points of contact						
1.1 Good working relationship with your partners' teams						
2. Trust in the abilities of the partners						
3. Well-planned collaborative design development process						
4. Joint problem-solving concerning this new product						
5. Joint decision-making concerning this new product						
6. Effective communication with your partners' teams						
6.1 Effective communication with your partners' main points of contact						
7. Clear, well-defined collaborative objectives						
8. Openly sharing information with your partners						
9. Innovative abilities of your in-house team						
10. Innovation culture of your organisation						
11. Top management commitment and support						
12. Commitment of the collaborative team						
13. Your adaptability to partners						
14. Working system adaptability of your in-house team						

☐ **After you have answered all the questions, did you realise these questioned issues during the collaboration?**

☐ **Do you get any new perspectives about collaboration from my research questions? If yes, What?**

☐ **Are there any more things you want to add on or say before we end the interview?**

Critical Factors in Collaborative Project Success for New Products

Question:
Please identify HOW CRITICAL THE FOLLOWING FACTORS WERE WHICH UNDERPINNED THE SUCCESS OF NEW PRODUCT COLLABORATION and GIVE ME YOUR REASONS TO SUPPORT ANY ANSWER

Command:
Please use THIS ASSESSMENT CARD A to identify the following indicators

ASSESSMENT CARD A

5 = EXTREMELY CRITICAL

4 = VERY CRITICAL

3 = IMPORTANT

2 = LITTLE IMPORTANT

1 = UNIMPORTANT

Thank you again for your time in the participation of my research

Interviewer: Chokeanand Bussracumpakorn

C-4 THE EXAMPLE OF QUESTIONNAIRE 4

Code **Date**

Project Name

Organisation

Interviewee

Place

Introduction

This study aims to examine underlying, critical factors which underpinned the success of new product collaboration between organisations. Regarding my position as academic researcher and an outsider of your collaborative project, who are interesting to investigate your retrospective experience and working procedures during the collaboration, therefore please help me answer any questions in details as much as you can, no matter how trivial or abstract the answers are, it will be essential for my study result.

The word 'critical' is mainly used for this study. **Critical factors** mean **the factors that are very significant. Lacking of these critical factors may cause problems, perils, ineffectiveness and/or failures during the collaboration.**

This questionnaire is divided into three parts:

Part 1: General questions concerning the collaborative project
Part 2: Focusing on critical factors concerning the future collaborative project
Part 3: Testing hypothetical factors for the collaborative project

☐ Please tick this block if you want your name to be anonymous

Please answer all the questions in the attached file and return it back via email.

1. GENERAL QUESTIONS ABOUT THE ORGANISATION AND COLLABORATIVE TEAM

1.1 INTRODUCTION

- ☐ **How the collaborative project started?**
- ☐ Why you collaborated with your partners?
- ☐ How well did you know your partners before the project started? (optional)

1.2 GENERAL ARRANGEMENT of/during COLLABORATION

- ☐ **How your organisation arranged the legal contract of this collaborative project?**
- ☐ What were essential agreements in the legal contract?
- ☐ What benefits did your organisation get from this collaboration?
- ☐ How the legal contract underpinned the success of the collaborative project?

- ☐ **How you arranged the collaborative working process with your partners?**
- ☐ What critical issues need to be concerned?
- ☐ What were your company roles?
- ☐ How many people mainly worked in the collaborative team across organisations?
- ☐ Are you the main point of contact during the collaboration?
- ☐ Any problems or conflicts of this working arrangement? If yes, What and Why?

- ☐ **How you communicated with your partners during the collaborative project?**
- ☐ What methods? Both informally and formally and how often?
- ☐ How effective of the methods?
- ☐ Any Problems of communication? If yes. What and Why and how you solved it?

- ☐ **How open you shared information to your partners?**
- ☐ How open your partners shared information to you?
- ☐ In your opinion, what was essential information for this new product?

- ☐ **Did you or your team need to adapt or adjust anything when you collaborated with your partners?**
- ☐ If yes. What and Why?

1.3 COLLABORATIVE DESIGN DEVELOPMENT PROCESS

- ☐ **Please tell me design development process during the collaboration**
- ☐ How was this process? (well-planned, informal, flexible and so on)
- ☐ Who initiated this process? Who planned it?
- ☐ Any problems or conflicts? What and why?

- ☐ **How the collaborative team across organisations solved design problems in the design process during the collaboration?**

(The collaborative team across organisations means a collective team from different organisations who work on the collaborative project.)

- ☐ **How the collaborative team across organisations made decisions about the solution of new design?**

1.4 THE RELATIONSHIP BETWEEN THE COLLABORATIVE TEAM

- ☐ **How was the relationship between you and your partners' main points of contact?**
- ☐ How close your personal relationship with your partners' main points of contact was? (professional relationship or friendship)
- ☐ How this relationship supported the success of collaboration?

- **How was the relationship between you and your partner's teams?**

1.5 IN-HOUSE TEAM

- **How many people worked in your in-house team for this collaborative project?**
- What they specialised?
- How they worked and communicated?
- Did they have a chance to communicate directly to your partners' teams?
- Did they need to adjust or adapt anything for this collaborative project? If yes. What and why?
- As a team leader, how you managed and encouraged your team regarding this collaborative project?

1.6 YOUR ORGANISATION

- **How your organisation supported this collaboration?**
- Any special supports?

- **What is the culture of innovation of your organisation?**
- For instance, working environment and process, communication, motivation and so on
- Do you think this culture supported the success of collaboration?

1.7 PROBLEMS DURING THE COLLABORATION

- **In general, did you have any problems or conflicts during the collaboration?**
- If yes. What and why?

- **If you could change or improve anything during the collaboration, what were you do? And WHY?**

Critical Factors in Collaborative Project Success for New Products

2. IDENTIFYING CRITICAL FACTORS

- ☐ **What were underlying critical factors <u>in the collaborative team across organisations</u> which underpinned the success of new product collaboration? And Why?**

- ☐ **What were underlying critical factors <u>in your team and organisation</u> which underpinned the success of new product collaboration? And Why?**

- ☐ **Regarding your role as the main point of contact during the collaboration, in your opinion, what was your critical contribution that supported the collaborative project success?**

3. MEASURING HYPOTHETICAL FACTORS

Please identify **how critical the following factors were which underpinned the success of this new product collaboration** and **give me your reasons to support your answers.**

Please make a mark in the box

HYPOTHETICAL FACTORS	Extremely Critical (5)	Very Critical (4)	Important (3)	Little Important (2)	Unimportant (1)	WHY?
3.1 Focusing on the main points of contact						
◆ Good interpersonal relationship between the main points of contact	5	4	3	2	1	
◆ Equal working relationship between the main points of contact	5	4	3	2	1	
◆ Trust in the abilities between the main points of contact	5	4	3	2	1	
◆ Effective informal communication between the main points of contact	5	4	3	2	1	
◆ Effective formal communication between the main points of contact	5	4	3	2	1	
◆ Open exchange of information between the main points of contact	5	4	3	2	1	
◆ Ability to communicate well by the main points of contact	5	4	3	2	1	
◆ Mutual respect between the main points of contact	5	4	3	2	1	
◆ Open-mindedness between the main points of contact	5	4	3	2	1	
◆ Amicable personality between the main points of contact	5	4	3	2	1	
◆ Understanding the distinctive roles of each other between the main points of contact	5	4	3	2	1	
◆ Commitment between the main points of contact	5	4	3	2	1	
◆ Adaptability between the main points of contact	5	4	3	2	1	
◆ Adjustment of communicative language between the main points of contact	5	4	3	2	1	
Focusing on the collaborative process (The collaborative team across organisations means a collective team from different organisations who work on the collaborative project.)						
◆ Clear, well-defined collaborative objectives	5	4	3	2	1	
◆ Mutual benefits of the collaborative project	5	4	3	2	1	
◆ Mutual trust in the abilities of the collaborative team across organisations	5	4	3	2	1	

Critical Factors in Collaborative Project Success for New Products

◆ Mutual understanding the distinctive abilities of the collaborative team across organisations	5	4	3	2	1	
◆ Close relationship of the collaborative team across organisations	5	4	3	2	1	
◆ Open exchange of information within the collaborative team across organisations	5	4	3	2	1	
◆ Well-planned collaborative design development process	5	4	3	2	1	
◆ Flexibility of collaborative design development process	5	4	3	2	1	
◆ Joint problem-solving concerning this new product	5	4	3	2	1	
◆ Joint decision-making concerning this new product	5	4	3	2	1	
◆ Effective informal communication within the collaborative team across organisations	5	4	3	2	1	
◆ Effective formal communication within the collaborative team across organisations	5	4	3	2	1	
◆ Commitment of the collaborative team across organisations	5	4	3	2	1	
◆ Adaptability of the collaborative team across organisations	5	4	3	2	1	
3.3 Focusing on your in-house team/organisations						
◆ Innovative abilities of your in-house team	5	4	3	2	1	
◆ Your team commitment	5	4	3	2	1	
◆ Flexibility of your team	5	4	3	2	1	
◆ Innovation culture of your organisation	5	4	3	2	1	
◆ Top management commitment and support	5	4	3	2	1	
◆ Your organisation structure	5	4	3	2	1	

Please give me the following comments:

☐ **After you have answered all questions, did you realise these questioned issues during the collaboration? And do you get any new perspectives about collaboration from my research questions? If yes, What?**

Thank you again for your time in the participation of my research

Interviewer: Chokeanand Bussracumpakorn

C-5: THE EXAMPLE OF TRANSCRIPTION

SG-CF (2) 1 CH: How about the silicon Gyroscope, is that start from that and then you work particularly on this product?

CF: As I said, it was all related to Silicon Gyro development in the very early stage. The prototype before the silicon was like silicon is miniature technology where you had have special equipment to actually process it. We were actually then looking initially at larger devices made out of metal ring which was the prototype for Silicon Gyro that was really where we noticed really a particular problem and approached DR. So it was really initially very small aspect, one aspect of the design of the product.

SG-CF (2) 11 CH: Before the project started, do you Dr Fox before?

CF: Not at all, as I said, it really through looking and reading a journal paper in the area. Obviously, there are a number of people who done theoretically investigation on sort of Gyro technology who worked in the academia. We are lucky that he was very well-known, very skilled in the area and live in UK. That was very good.

CH: Actually, do you have process to select the partnership normally?

CF: Not really, and it is very much on our top basis. Generally, we will look at to have all the skill that we need in-house.

CH: Is this special case for the company?

SG-CF (2) 20 *CF: It is very much special case, I think. For this sort of collaboration, certainly in my experiences it is very much on needs. Certainly, when you need to do it you will do it. It's not something that we don't set out to find partner. Or we rather, it is better if you have all the capabilities internally. Because and obviously, you have control of your resources. Obviously, we employ our people rather than spending money outside.*

CH: What the difference?

CF: Well basically, anything we spend outside was additional expenses on the company. So, it costs money to employ and that better if people like myself can do the work rather recruit more people

SG-CF (2) 31 CH: How you managed collaboration

APPENDIX D:

OTHER PAPERS BY THE AUTHOR

1. The second published conference paper,

   Bussracumpakorn, C (2002). *The study of the UK SMEs employing external organisations to support innovative products*. At Design Research Society International Conference 2002, Common Ground, 5-7 September 2002, Brunel University, London UK.

2. The first published conference paper,

   Bussracumpakorn, C (2002). *Links with other organisations in sustaining innovative products*. At Proceedings of The European Academy of Management 2nd Annual Conference on Innovative Research in Management, EURAM, 9-11 May 2002, Stockholm Sweden 2002